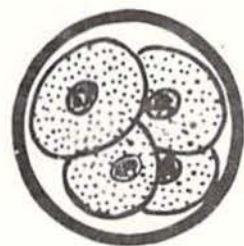
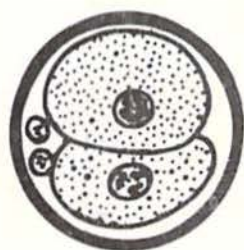


ATLAS OF EMBRYOLOGY



by
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PREFACE

This " ATLAS OF EMBRYOLOGY " contains over 280 illustrations which are presented systematically to cover both general embryology and special embryology. It is intended to help medical students overcome the difficulties in understanding the principles of human embryology. The diagrams are all line drawings which are provided with enough labels and necessary explanations presented in legend form.

The authors hope that this atlas would be of benifit to undergraduate and postgraduate medical students who may find it a useful guide to human embryology.

CAIRO, 1986

FAWZI GABALLAH

ZAIZAFON BADAWY

OTHER BOOKS BY PROF. FAWZI GABALLAH

1. Basic Embryology.
2. Basic Anatomy (a detailed textbook).
3. Atlas of Anatomy.
4. Basic Neuroanatomy.
5. Atlas of Neuroanatomy.
6. A Summary of Anatomy.
7. Oral Questions in Anatomy.
8. Spotting (a guide to practical anatomy).

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PART (I)

GENERAL EMBRYOLOGY

MALE GENITAL ORGANS

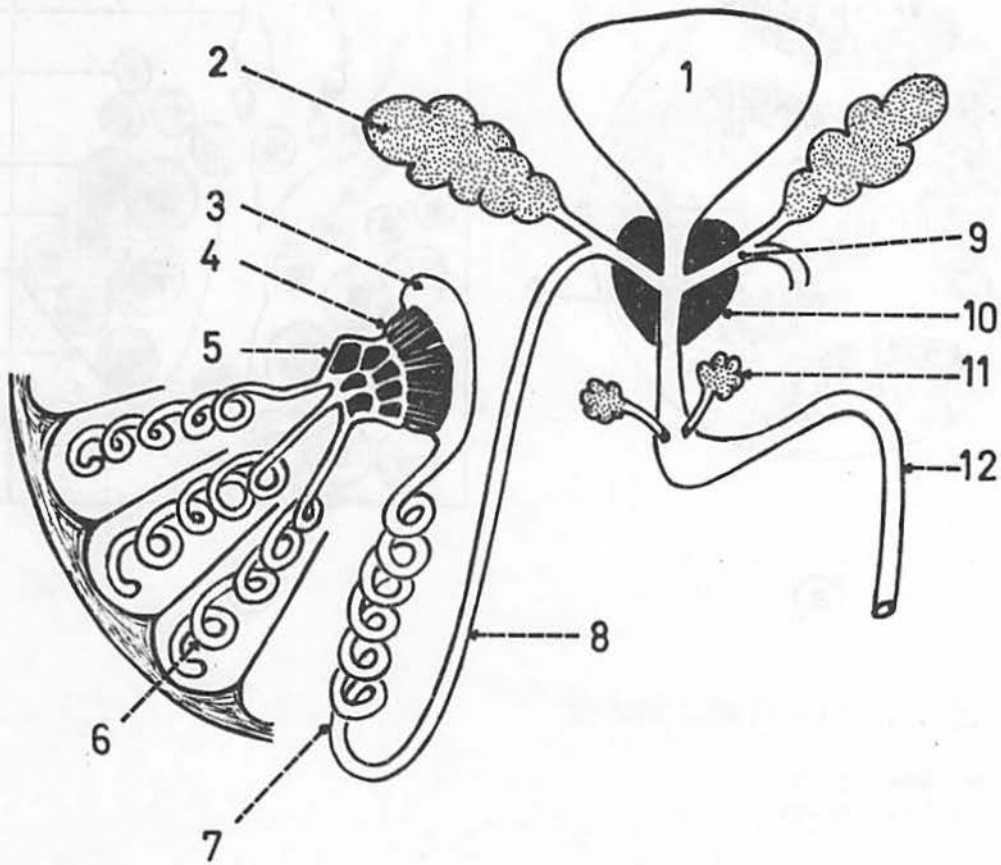


Fig.(1): MALE GENITAL ORGANS

1. urinary bladder.
2. seminal vesicle.
3. head of epididymis.
4. vasa efferentia (efferent ductules).
5. rete testis.
6. seminiferous tubules.
7. tail of epididymis.
8. ductus (vas) deferens.
9. ejaculatory duct.
10. prostate.
11. bulbo-urethral gland.
12. penile urethra.

* The sperms are formed in the seminiferous tubules and pass through the following ducts: rete testis, vasa efferentia, epididymis, ductus deferens, ejaculatory duct and finally the urethra.

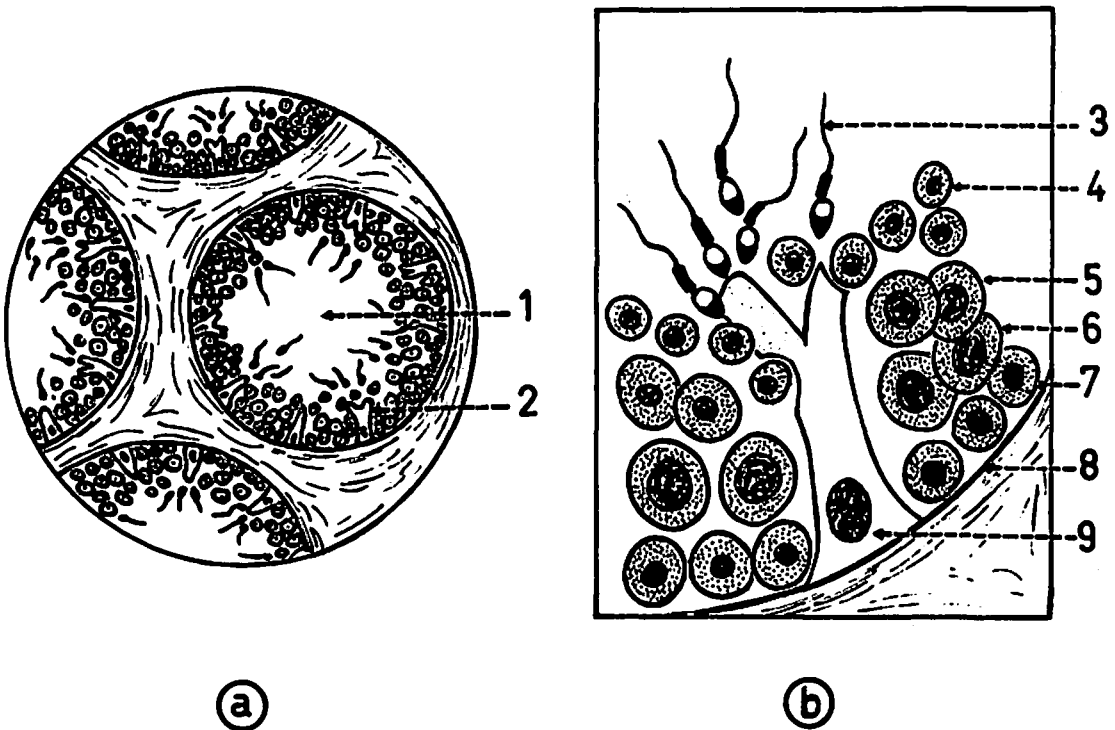


Fig.(2): T.S. IN SEMINIFEROUS TUBULE

- (a) low power
(b) high power

1. lumen of seminiferous tubule .
2. wall of the tubule.
3. sperm.
4. spermatid.
5. secondary spermatocyte.
6. primary spermatocyte.
7. spermatogonium.
8. basement membrane.
9. Sertoli cell.

* The wall of the seminiferous tubule consists of both germ cells and Sertoli cells. The germ cells are arranged in layers with those lying on the basement membrane are the most primitive and called spermatogonia, while those near the lumen are more mature and called spermatocytes and spermatids.

FEMALE GENITAL ORGANS

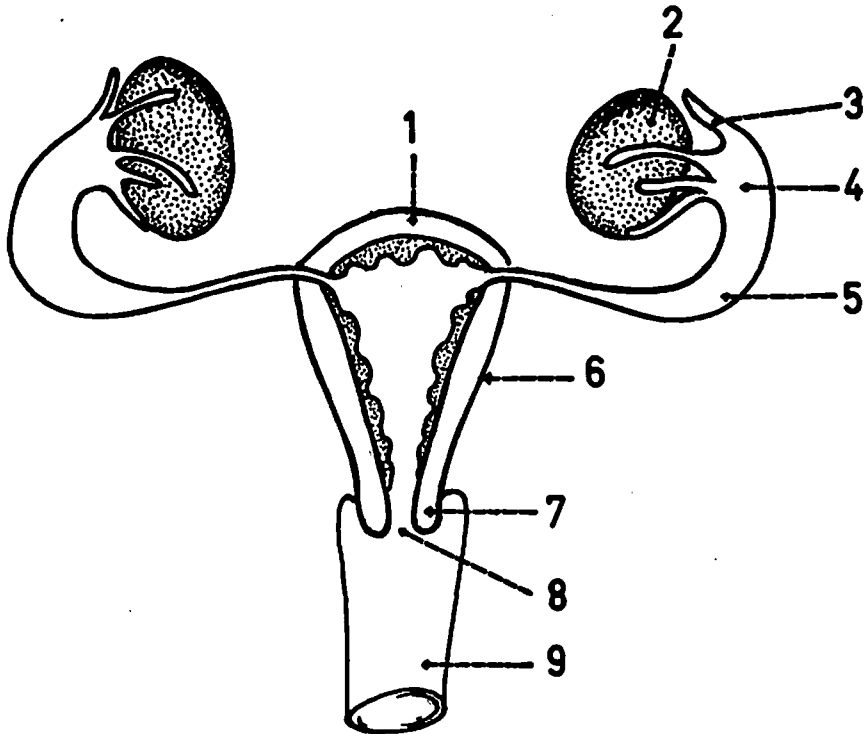


Fig.(3): FEMALE GENITAL ORGANS

1. fundus of uterus.
2. ovary.
3. fimbria.
4. lateral end of uterine tube.
5. ampullary part of uterine tube.
6. body of uterus.
7. cervix of uterus.
8. external os.
9. vagina.

* The ampullary part of the uterine tube is the most dilated part, and is the part of the tube in which fertilization of the ovum takes place.

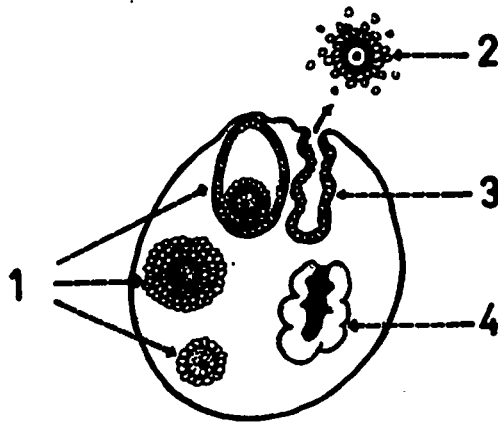


Fig.(4): OVARY WITH OVARIAN FOLLICLES

1. ovarian follicles at various stages of maturation.
2. ovum extruded from ruptured Graafian follicle.
3. ruptured Graafian follicle.
4. corpus luteum.

N.B.: All ovarian follicles lie in the cortex of the ovary but not in the medulla.

SPERMATOGENESIS

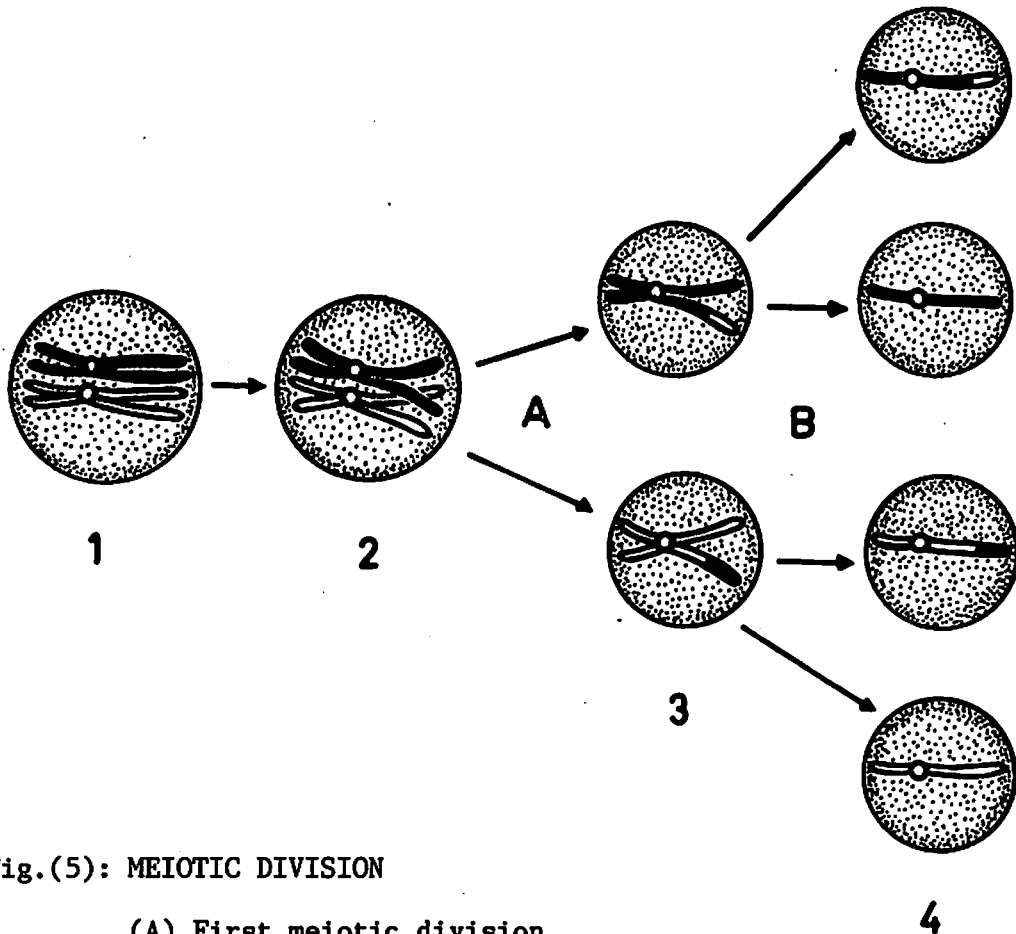


Fig.(5): MEIOTIC DIVISION

- (A) First meiotic division
(B) Second meiotic division

1. sex cell with diploid number of chromosomes ($2n$).
2. crossing-over (between homologous chromosomes).
3. two cells each of which has haploid number of chromosomes (the result of 1st meiotic division).
4. four cells each of which has haploid number of chromosomes (each chromatid will complete itself to form a full chromosome).

* The 1st meiotic division is the stage at which the number of chromosomes is reduced to its half, while the 2nd meiotic division is mitotic in nature with no reduction in the number of chromosomes.

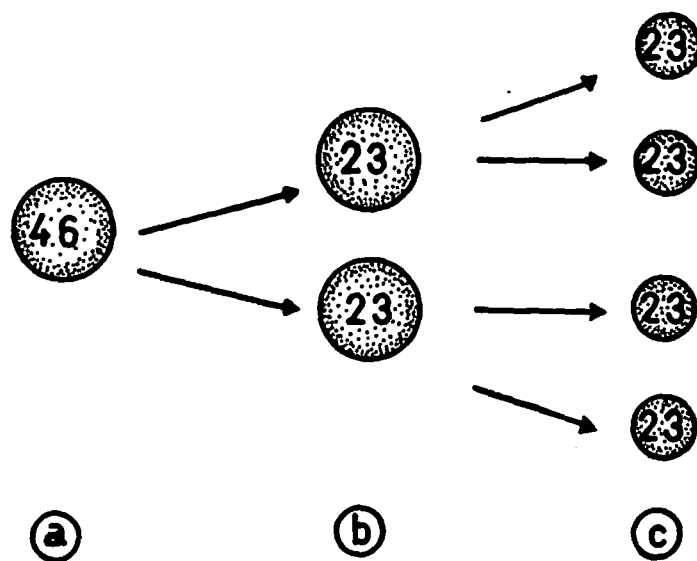


Fig.(6): GENETICAL CHANGES IN SPERMATOGENESIS

- (a) primary spermatocyte ($2n$).
- (b) secondary spermatocyte (n).
- (c) spermatids (n).

N.B.: One primary spermatocyte gives rise to 4 spermatids.

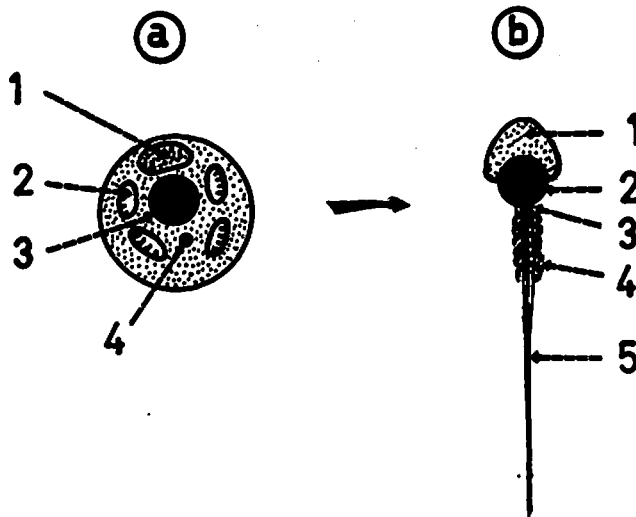


Fig.(7): SPERMIOGENESIS

- (a) Spermatid:
 1. Golgi apparatus; 2. mitochondria; 3. nucleus; 4. centriole.
- (b) Complete sperm:
 1. head cap (Golgi apparatus); 2. head (nucleus); 3. neck; 4. middle piece (sheath of mitochondria); 5. tail (elongated centriole).

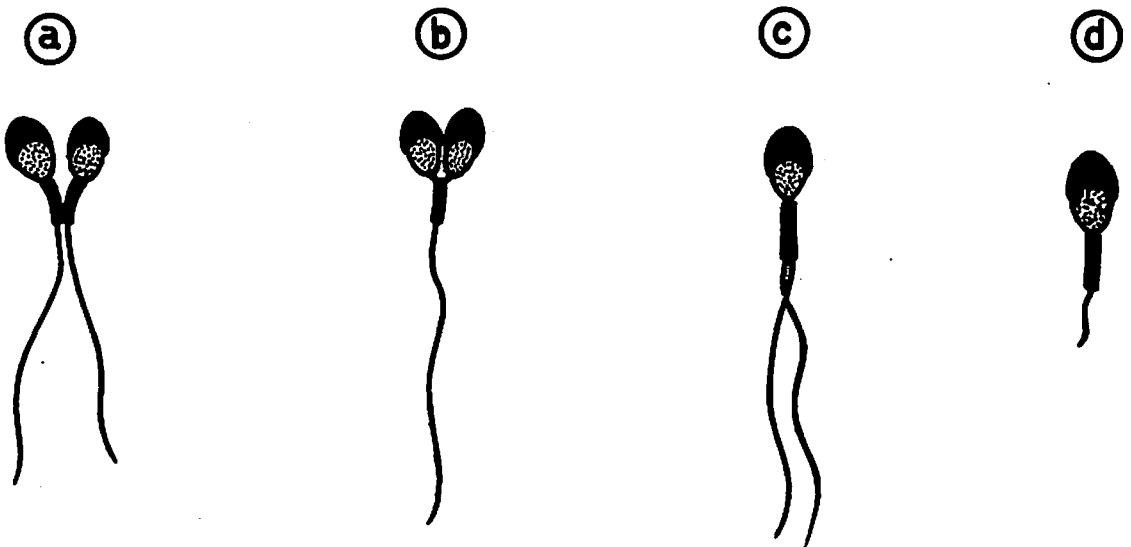


Fig.(8): ABNORMAL FORMS OF SPERMS

- (a) joined sperms.
 (b) sperm with double heads.
 (c) sperm with double tails.
 (d) sperm with very short tail.

OOGENESIS

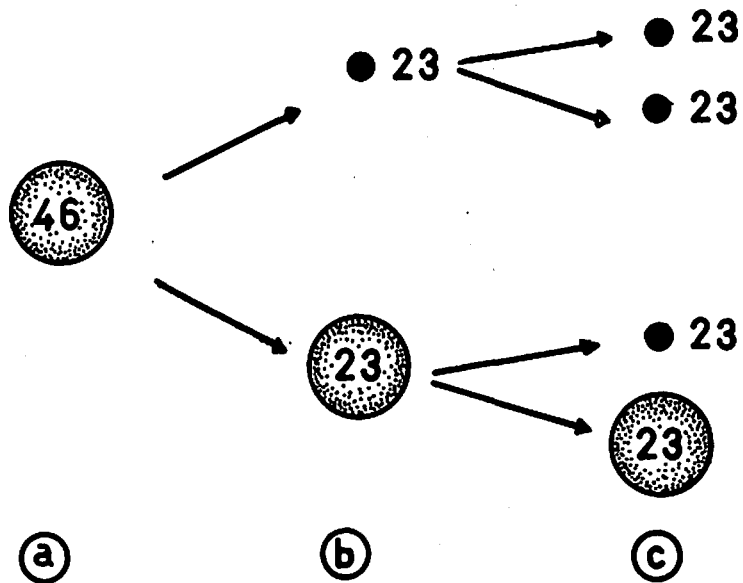
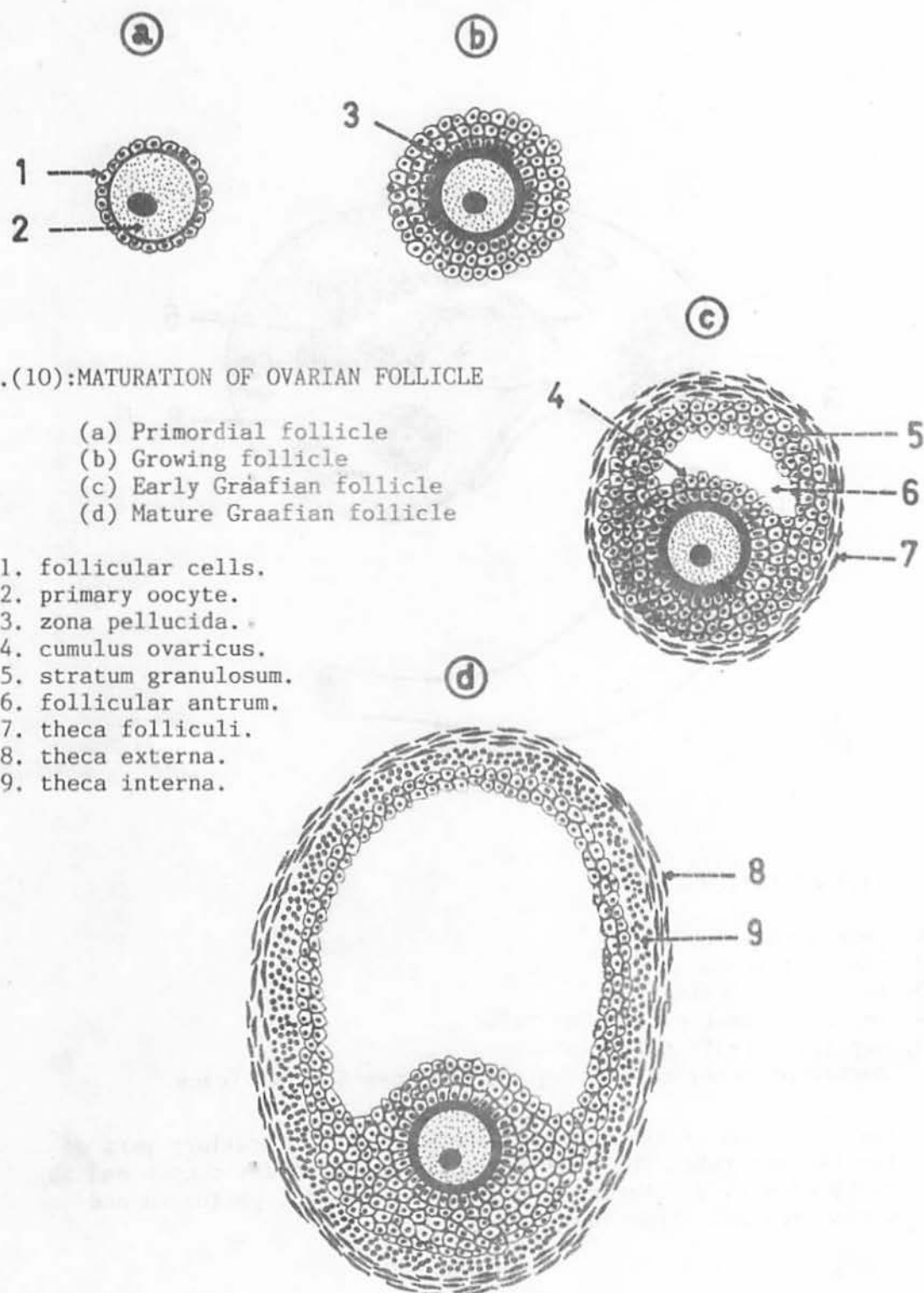


Fig.(9): GENETICAL CHANGES IN OOGENESIS

- (a) primary oocyte ($2n$).
- (b) one secondary oocyte (n) and one polar body.
- (c) one mature ovum (n) and three polar bodies.

N.B.: One primary oocyte gives rise to one mature ovum only.



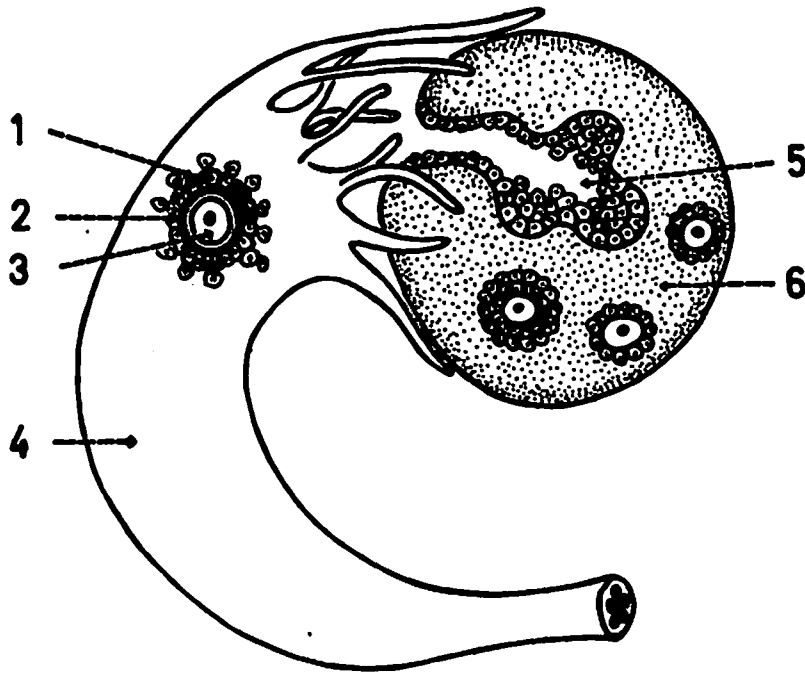


Fig.(11): OVULATION

1. corona radiata.
2. zona pellucida.
3. secondary oocyte.
4. ampullary part of uterine tube.
5. ruptured Graafian follicle.
6. cortex of ovary containing immature ovarian follicles.

* Fertilization of the ovum takes place in the ampullary part of the uterine tube. The ovum is in the stage of 2ry oocyte and is surrounded by 3 coverings: cell membrane, zona pellucida and corona radiata (from inside outwards).

Fig.(12) CORPUS LUTEUM

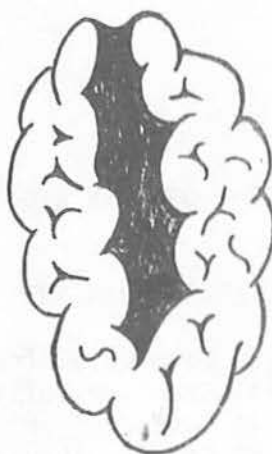


Fig.(13): ABNORMAL FOLLICLE WITH TWO OOCYTES

Ovulation of this type gives rise to 2 ova which if fertilized result in dizygotic twins.



Fig.(14): SECRETORY PHASE OF ENDOMETRIUM

1. stroma cells.
2. helicine artery.
3. uterine gland (distended with secretions).

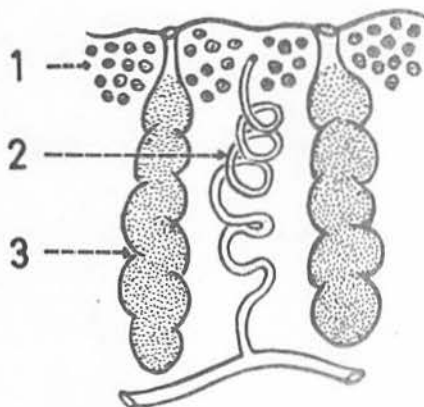


Fig.(15): OVARIAN AND MENSTRUAL CYCLES

I- OVARIAN CHANGES:

- (a) Primordial follicle.
- (b) Graafian follicle.
- (c) Ovulation and corpus luteum formation.
- (d) Corpus albicans (in absence of fertilization).

II- HORMONAL CHANGES:

- (a) Oestrogen hormone: reaches maximum level just before ovulation then declines after ovulation.
- (b) Progesterone hormone: only appears after ovulation and declines with degeneration of corpus luteum.

III- ENDOMETRIAL CHANGES:

- (a) Stage of menstrual blood flow: basal parts of uterine arteries, basal parts of uterine glands and few stroma cells (from above downwards).
- (b&c) Proliferative stage: long straight arteries, long straight glands and increased number of stroma cells.
- (d) Secretory phase: helicine arteries, distended glands and large-sized stroma cells.

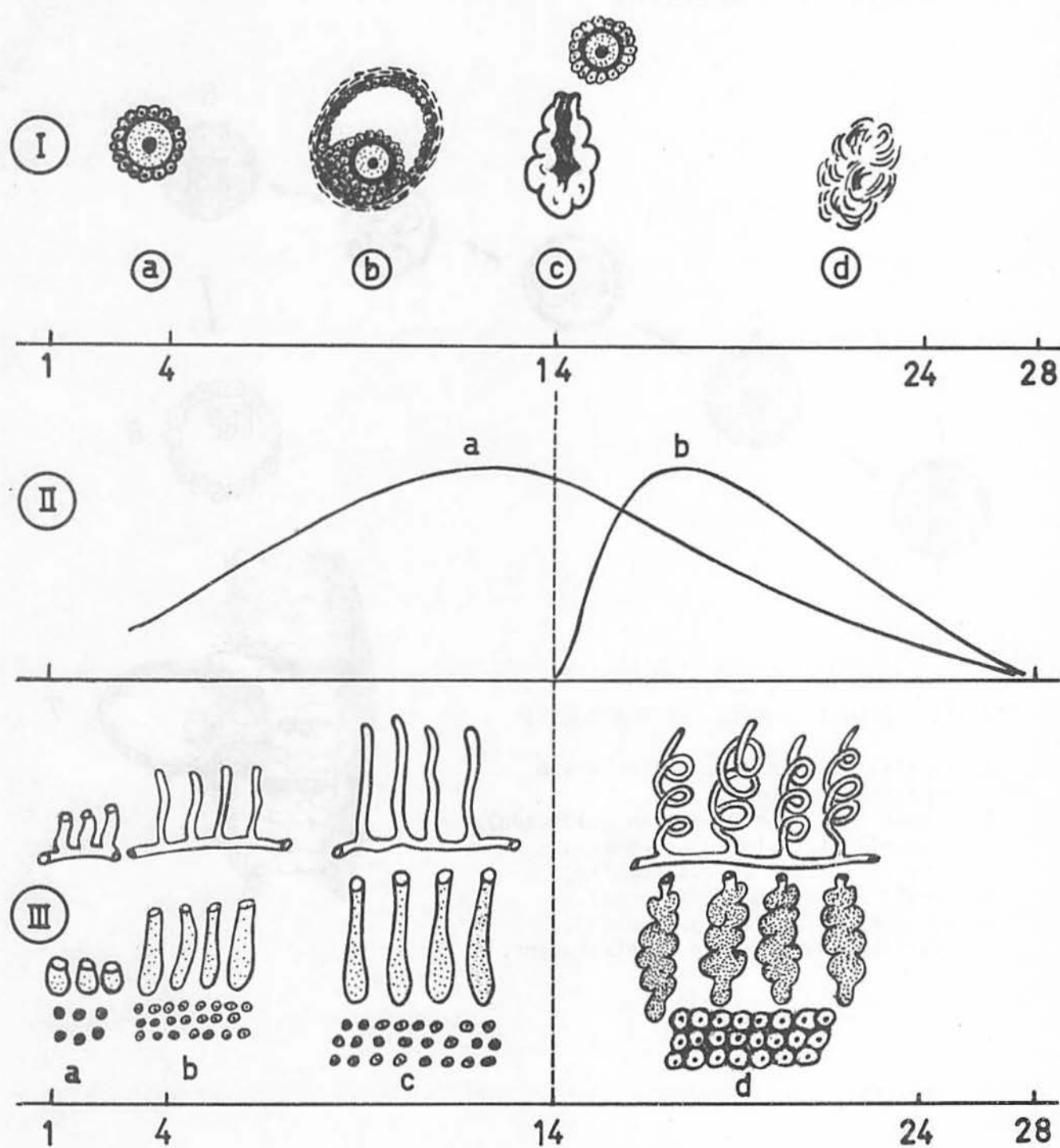


Fig.(15): OVARIAN AND MENSTRUAL CYCLES

FERTILIZATION AND SEGMENTATION

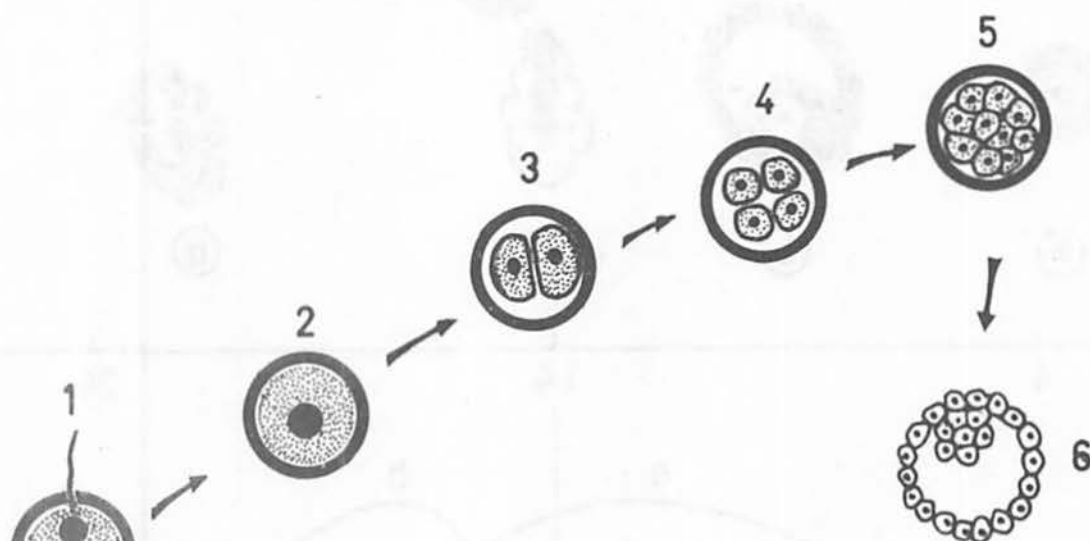
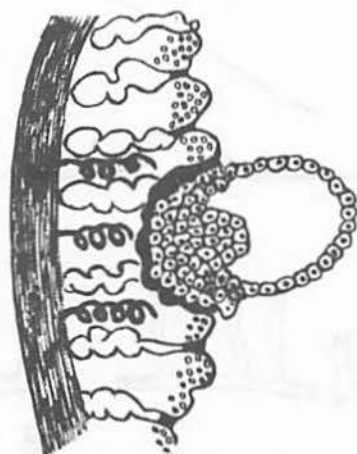


Fig.(16): ZYGOTE, MORULA AND BLASTOCYST

1. fertilization (fusion of male and female pronuclei).
2. zygote (surrounded by zona pellucida).
3. two-cell stage (2 blastomeres).
4. four-cell stage (4 blastomeres).
5. morula (about 16 blastomeres).
6. blastocyst (no zona pellucida).
7. starting implantation of blastocyst.



IMPLANTATION

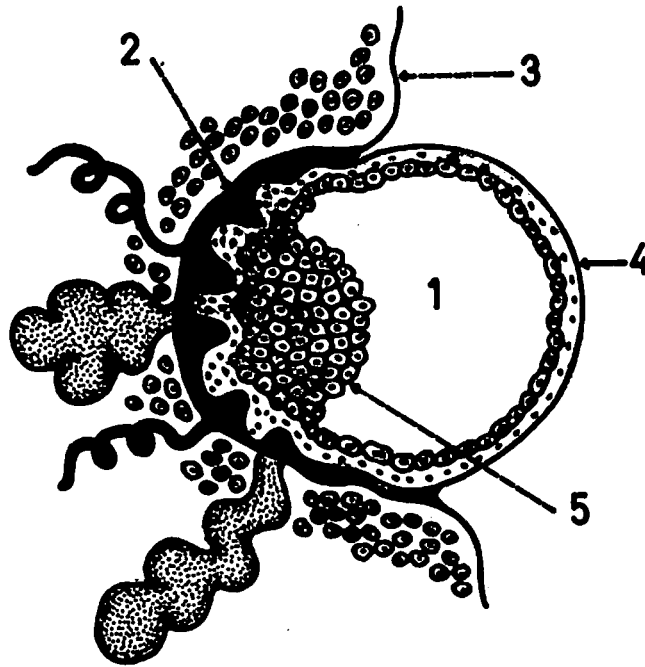


Fig.(17): IMPLANTATION OF THE BLASTOCYST

1. blastocele (cavity of the blastocyst).
2. implantation cavity in the endometrium (filled with blood).
3. endometrium in the secretory stage (called decidua).
4. outer cell mass of the blastocyst (future trophoblast). This pole of blastocyst is the ab-embryonic pole.
5. inner cell mass (future embryo).

N.B.: The blastocyst gets implanted by its embryonic pole which is the pole over the inner cell mass. The pole opposite to the embryonic pole is the ab-embryonic pole.

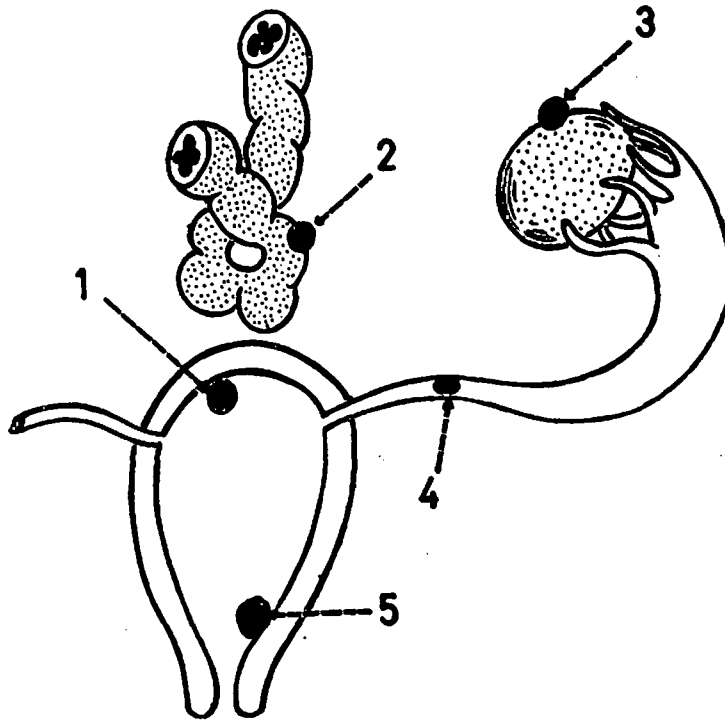


Fig.(18): NORMAL AND ABNORMAL SITES OF IMPLANTATION

1. normal site (in upper part of posterior wall of uterus).
2. abdominal pregnancy (attached to abdominal viscera).
3. ovarian pregnancy (attached to the ovary).
4. tubal pregnancy (in uterine tube).
5. placenta praevia (in lower segment of uterus).

N.B.: Implantation outside the uterus is called ectopic pregnancy and it never reaches full-term.

DECIDUA

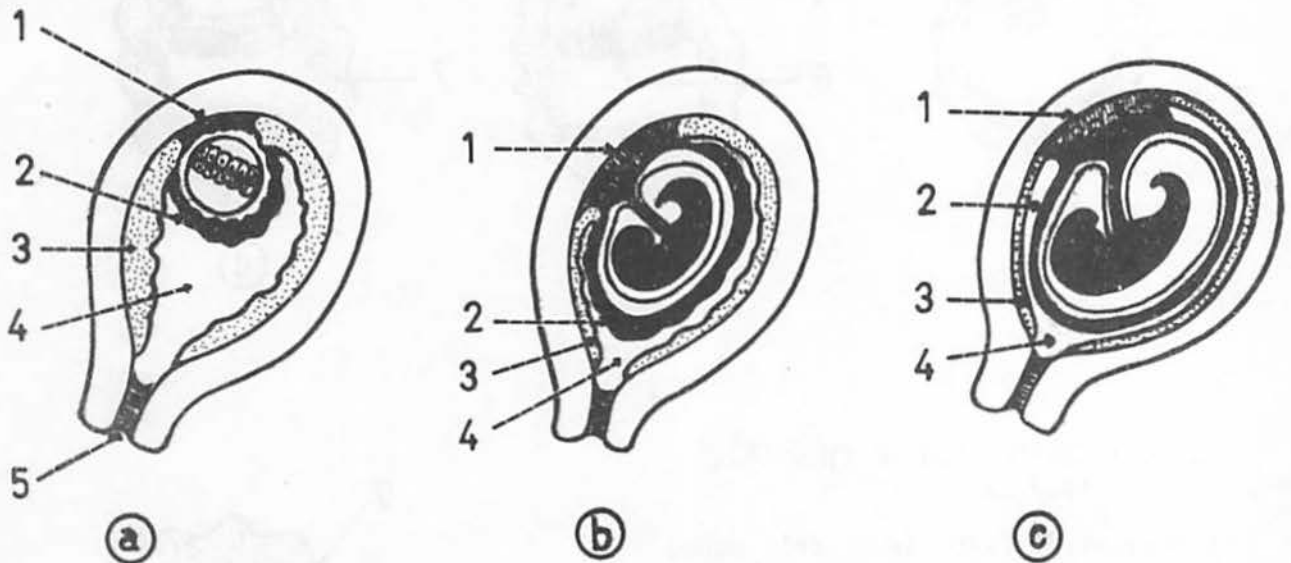


Fig.(19): PARTS OF THE DECIDUA

- (a) Early stage
- (b) Bulging of the blastocyst into the uterine cavity
- (c) Fusion of the decidua capsularis with the decidua parietalis

- 1. decidua basalis (at the base of blastocyst).
- 2. decidua capsularis (superficial to the blastocyst).
- 3. decidua parietalis (lines the wall of the uterus, away from the blastocyst).
- 4. uterine cavity.
- 5. cervical mucus plug.

CHORIONIC VESICLE

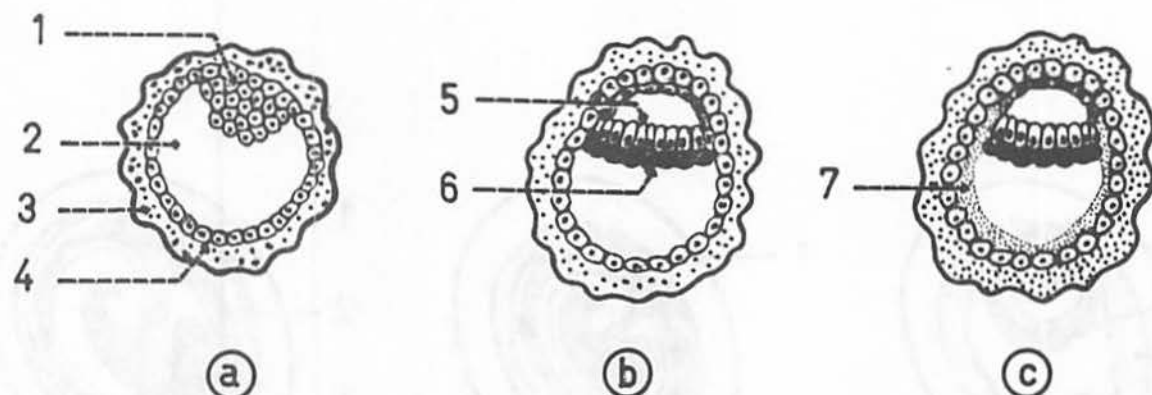
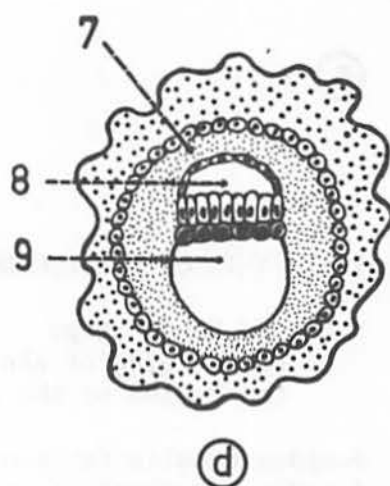


Fig.(20): DEVELOPMENT OF CHORIONIC VESICLE

- (a) Blastocyst (with inner cell mass)
 (b) Blastocyst (with bilaminar disc)
 (c) Chorionic vesicle (early stage)
 (d) Chorionic vesicle (advanced stage)



1. inner cell mass.
2. blastocoel.
3. syncytiotrophoblast.
4. cytotrophoblast.
5. dorsal ectodermal layer of embryonic disc.
6. ventral endodermal layer of embryonic disc.
7. extra-embryonic mesoderm.
8. amniotic cavity (its roof is formed by amniogenic cells).
9. primary (primitive) yolk sac (its sides and floor are lined with Hauser's membrane which is mesodermal in origin).

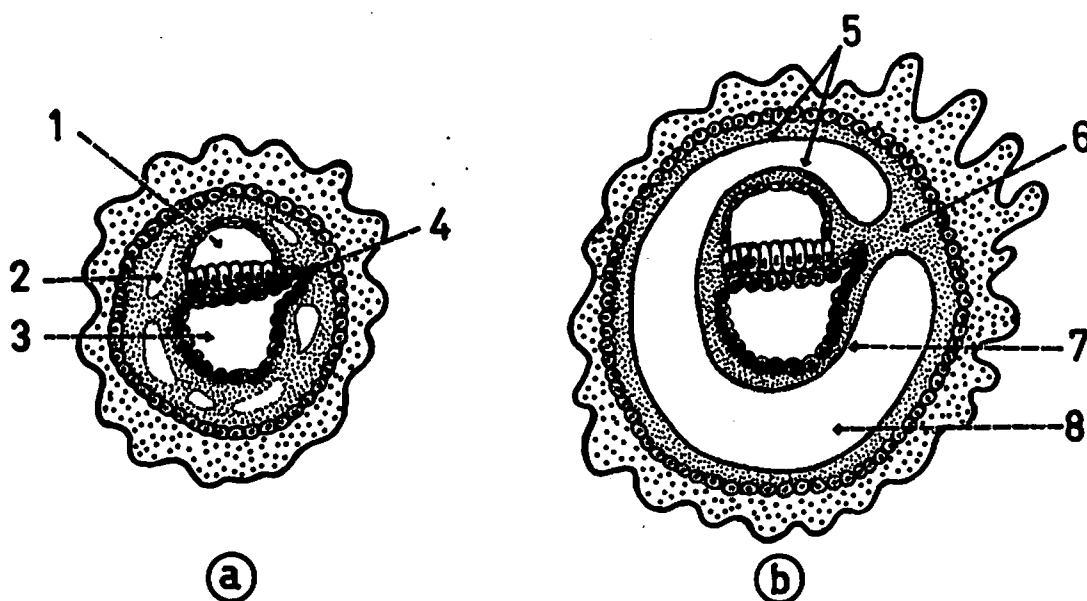


Fig.(21): EXTRA-EMBRYONIC COELOM

- (a) Early stage (separate clefts)
 (b) Advanced stage (one continuous cavity)

1. amniotic cavity.
2. coelomic cleft inside the extra-embryonic mesoderm.
3. secondary yolk sac (lined all through with endoderm).
4. allantois (allanto-enteric diverticulum).
5. somatopleuric mesoderm (lining the wall of the vesicle and covering the amnion as well).
6. connecting stalk (at the caudal end of the disc).
7. splanchnopleuric mesoderm (covering the yolk sac only).
8. extra-embryonic coelom (one continuous cavity).

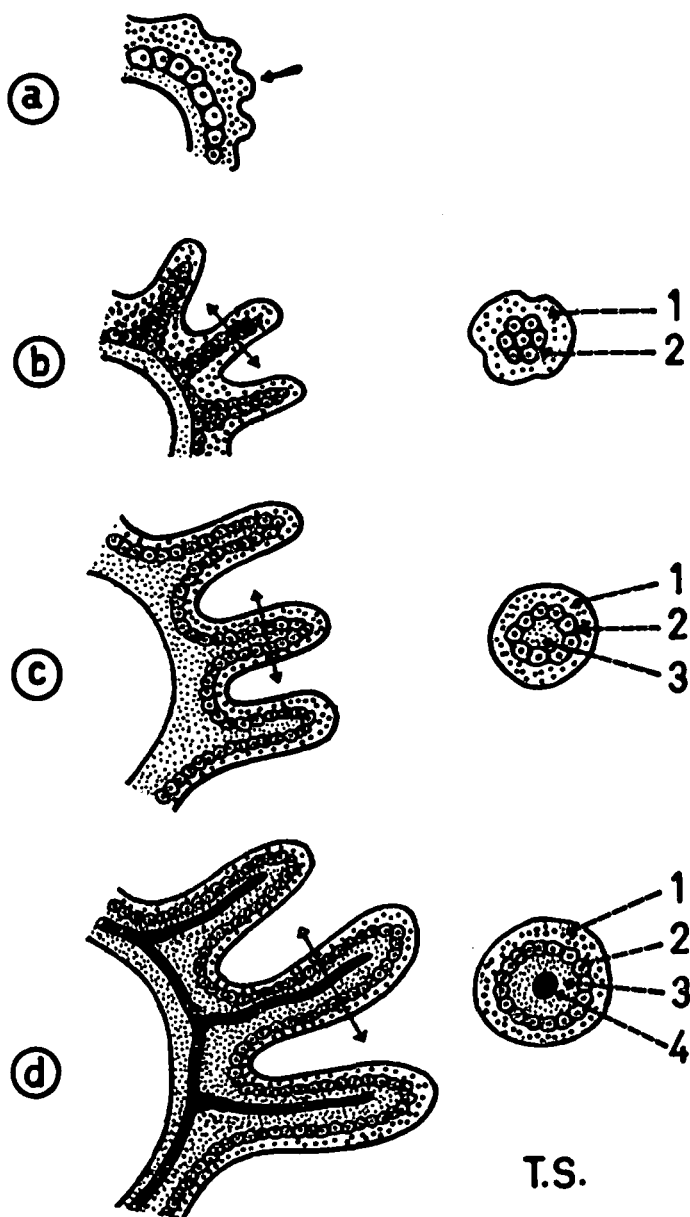


Fig.(22): CHORIONIC VILLI

- (a) Chorionic trabeculae (syncytiotrophoblast only)
- (b) Primary villus (syncytiotrophoblast and cytotrophoblast)
- (c) Secondary villus (has a core of mesoderm)
- (d) Tertiary villus (contains blood vessels)

- 1. syncytiotrophoblast.
- 2. cytotrophoblast.
- 3. extra-embryonic mesoderm (core of the villus).
- 4. blood vessel in the mesodermal core.

PLACENTA

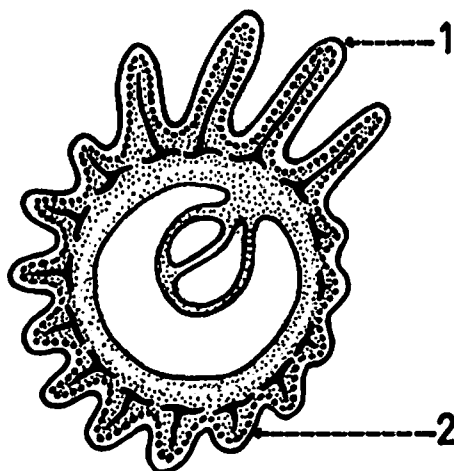


Fig.(23): CHORION FRONDOSUM AND CHORION LAEVE

1. chorion frondosum.
2. chorion laeve.

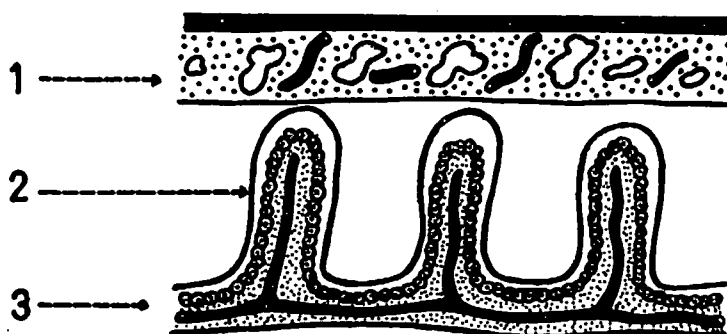


Fig.(24): EARLY STAGE OF PLACENTA

1. decidua basalis (forms the basal plate).
2. chorion frondosum (gets attached to the decidua basalis).
3. wall of chorionic vesicle (called chorion and forms the chorionic plate).

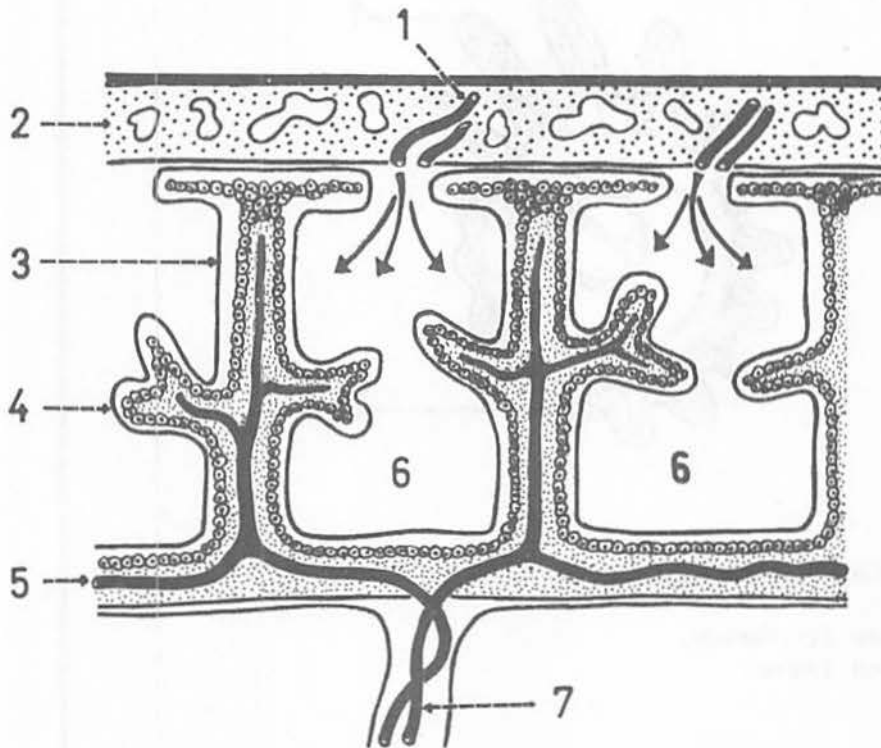


Fig.(25): ADVANCED STAGE OF PLACENTA

1. uterine vessels opening into the intervillous space.
2. basal plate (decidua basalis).
3. stem (anchoring) villus.
4. absorbing (floating) villus.
5. chorionic plate (wall of chorionic vesicle).
6. intervillous space (filled with maternal blood).
7. foetal blood vessels in the umbilical cord and ramifying inside the chorionic villi.

N.B.: The maternal blood never mixes with the foetal blood but a placental barrier always intervenes.

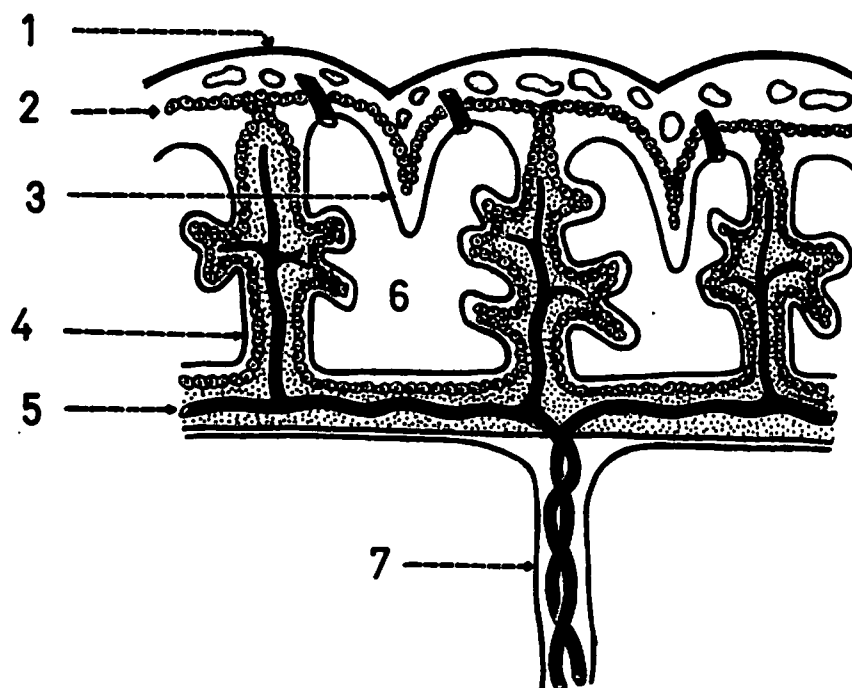


Fig.(26): FULL-TERM PLACENTA

1. cotyledon (on the rough maternal surface).
2. cytotrophoblastic shell.
3. placental septum (does not reach the chorionic plate).
4. stem villus.
5. chorionic plate (forms the smooth foetal surface).
6. intervillous space.
7. umbilical cord attached to the chorionic plate.

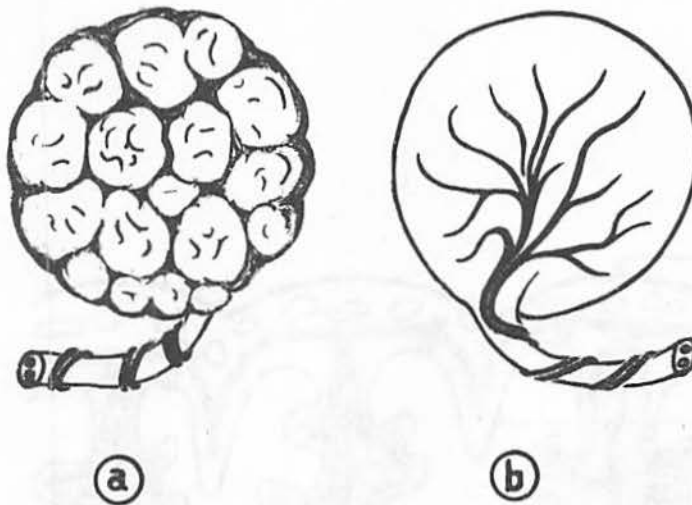


Fig.(27): GROSS MORPHOLOGY OF PLACENTA

- (a) Maternal surface: rough with cotyledons which are (15-20) elevated areas.
- (b) Foetal surface: smooth with the umbilical cord attached to it near its centre.

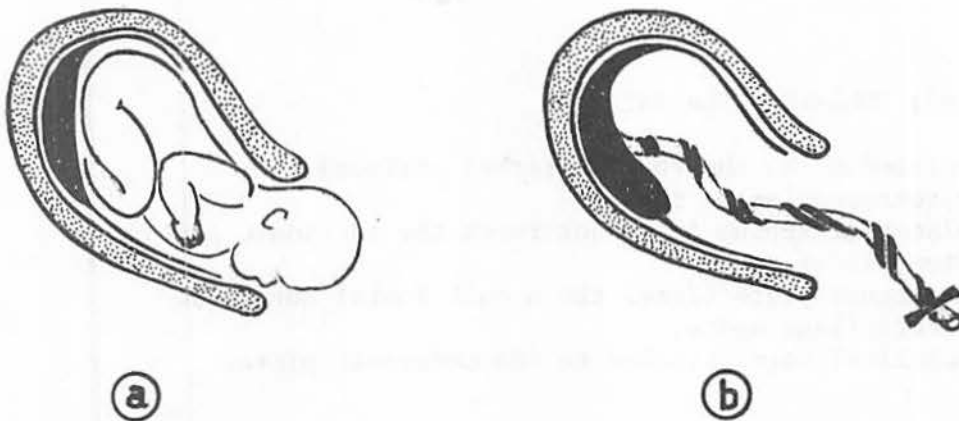


Fig.(28): NORMAL POSITION OF PLACENTA

- (a) The placenta is attached high up near the fundus.
- (b) Immediately after birth (normally the child is delivered before the placenta).

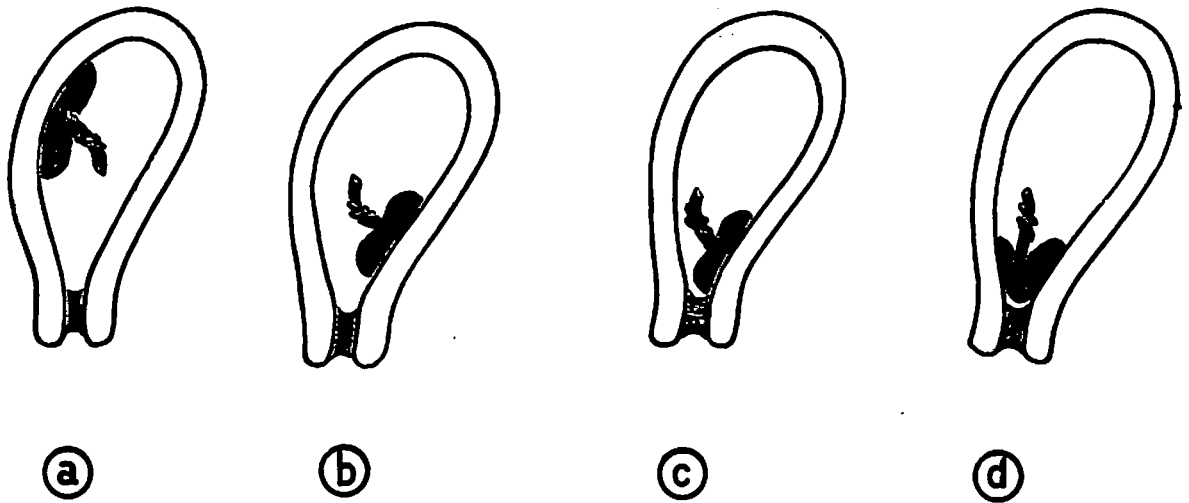


Fig.(29): PLACENTA PRAEVIA

- (a) Normal site of placenta (near the fundus).
- (b) Placenta praevia lateralis (near the margin of internal os of cervix).
- (c) Placenta praevia marginalis (partially overlies the internal os).
- (d) Placenta praevia centralis (completely overlies the internal os).

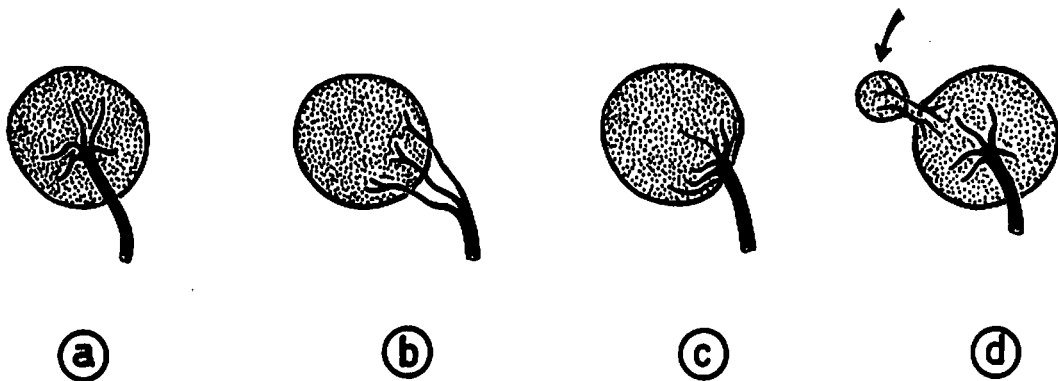


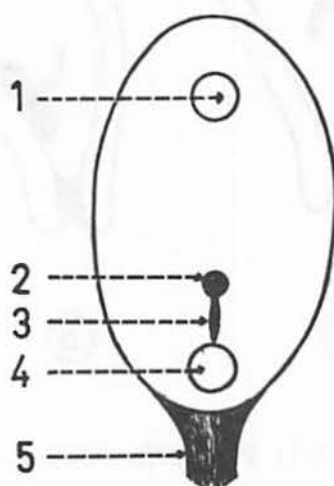
Fig.(30): ABNORMAL FORMS OF PLACENTA

- (a) Normal attachment of the cord (near the centre).
- (b) Velamentous placenta (the cord is attached to the adjoining membranes away from the placenta).
- (c) Battledore placenta (the cord is attached to the margin of the placenta).
- (d) Accessory placenta (placenta succinturiata) (marked by arrow).

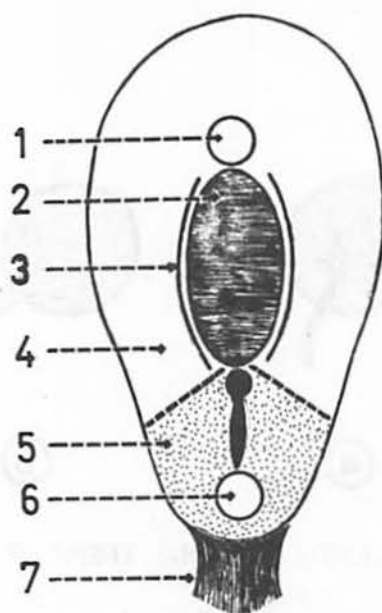
EMBRYONIC (GERM) DISC

Fig.(31): OVAL-SHAPED EMBRYONIC DISC

1. buccopharyngeal membrane.
2. primitive node.
3. primitive streak.
4. cloacal membrane.
5. connecting stalk.

Fig.(32): PEAR-SHAPED EMBRYONIC DISC
(from dorsal aspect)

1. buccopharyngeal membrane.
2. neural plate.
3. neural crest.
4. skin ectoderm.
5. pluripotent ectoderm.
6. cloacal membrane.
7. connecting stalk.



NEURAL TUBE

Fig.(33): DEVELOPMENT OF NEURAL TUBE

(a) Neural plate:

Extends from the primitive node to the buccopharyngeal membrane, and has a neural crest at each edge.

(b&c) Neural groove.

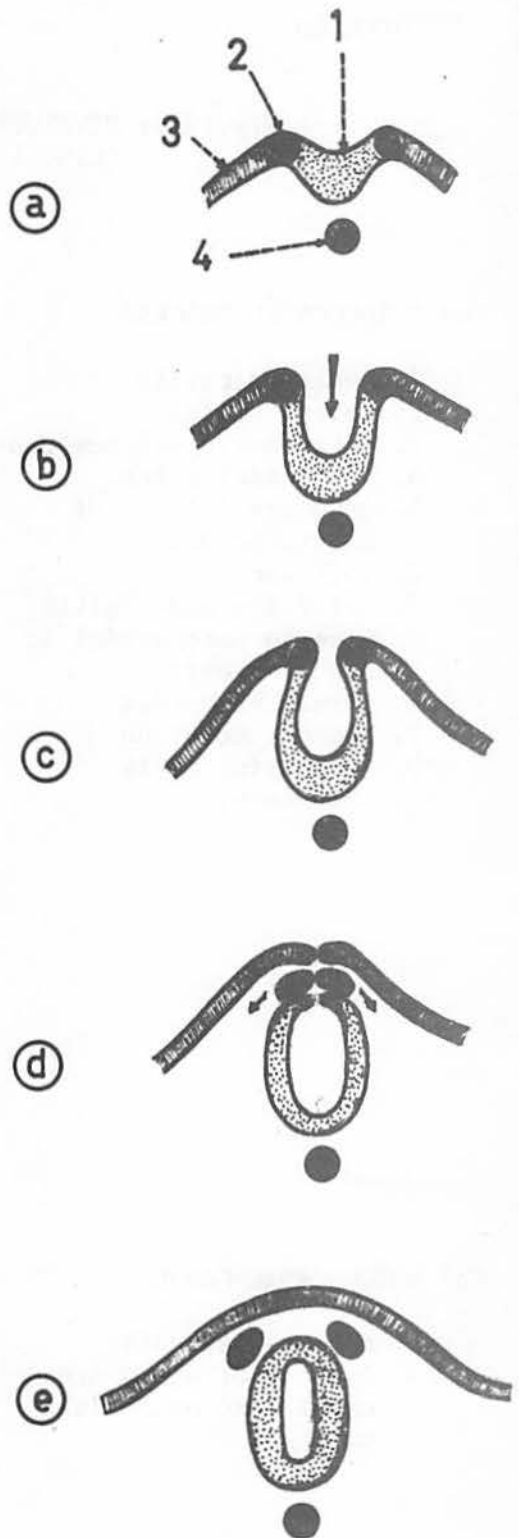
(d) Beginning of fusion of the neural folds:

The skin of one side fuses with skin of the opposite side, and neurectoderm of one side fuses with neurectoderm of the opposite side.

(e) Neural tube:

The two neural crests remain separate, one on each side.

1. neural plate (neurectoderm).
2. neural crest.
3. skin ectoderm.
4. notochord.

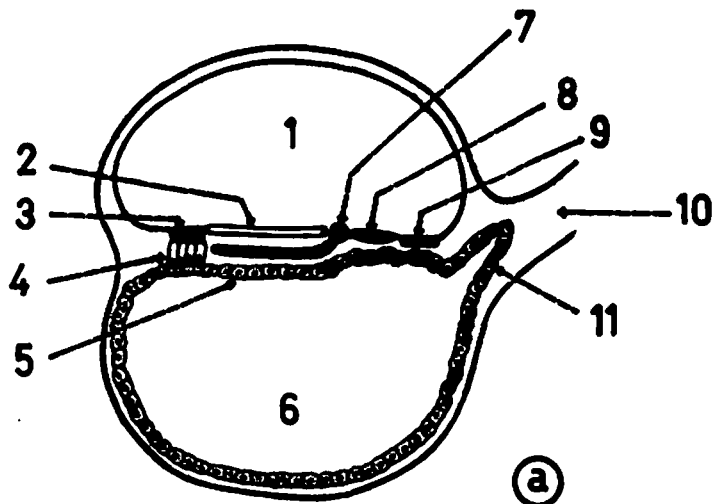


NOTOCHORD

Fig.(34): DEVELOPMENT OF NOTOCHORD
(L.S. in the midline of the disc)

(a) NOTOCHORDAL PROCESS

1. amniotic cavity.
2. neural plate.
3. buccopharyngeal membrane.
4. prochordal plate.
5. endodermal layer of embryonic disc.
6. yolk sac.
7. primitive node (giving rise to notochordal or head process).
8. primitive streak.
9. cloacal membrane.
10. connecting stalk.
11. allantois.



(b) NOTOCHORDAL CANAL

12. notochordal canal.
13. opening of notochordal canal into amniotic cavity.

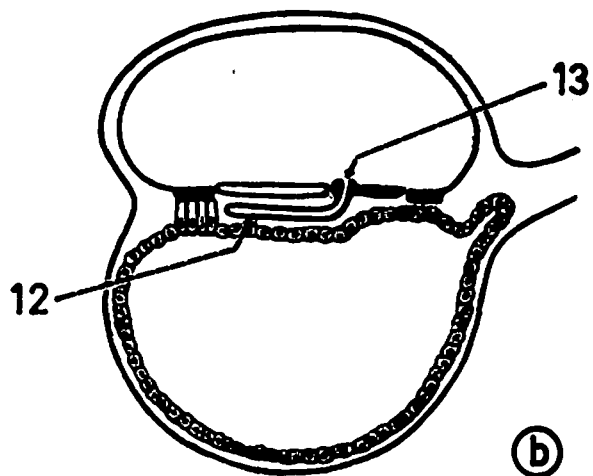
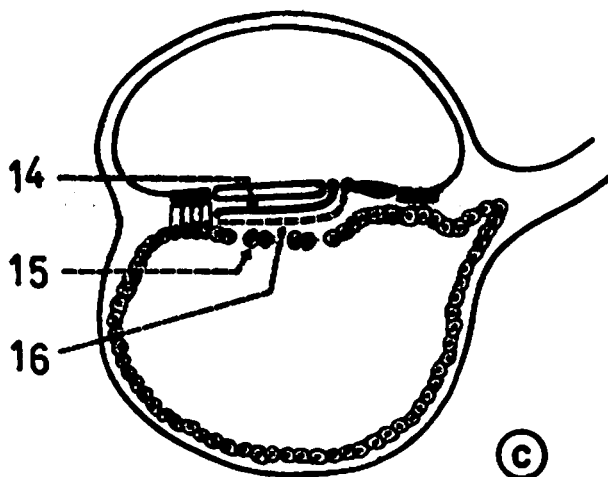


Fig.(34): DEVELOPMENT OF NOTOCHORD
(continued)

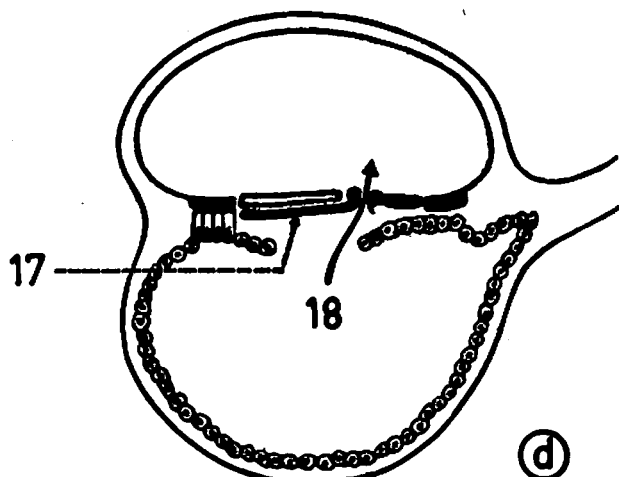
(c) DEGENERATION OF THE FLOOR OF NOTOCHORDAL CANAL

- 14. roof of notochordal canal.
- 15. degenerating endoderm of roof of yolk sac.
- 16. degenerating floor of notochordal canal.



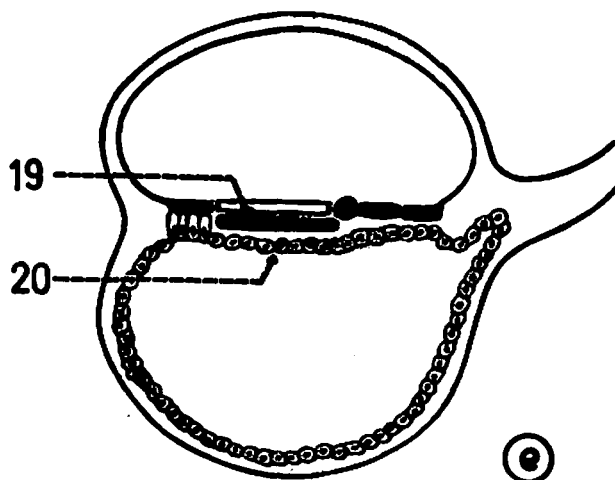
(d) DISAPPEARANCE OF THE FLOOR OF NOTOCHORDAL CANAL AND FORMATION OF NEURENTERIC CANAL

- 17. roof of notochordal canal.
- 18. neurenteric canal.



(e) DEFINITIVE NOTOCHORD AND REGENERATION OF THE ROOF OF YOLK SAC

- 19. definitive notochord.
- 20. regenerated roof of yolk sac.



INTRA-EMBRYONIC MESODERM AND COELOM

Fig.(35): FORMATION OF INTRA-EMBRYONIC MESODERM

The arrows show how the mesoderm arises from the primitive node and primitive streak, and spreads laterally, cranially and caudally.

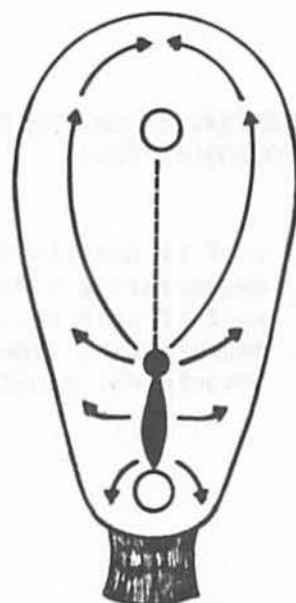


Fig.(36): DIFFERENTIATION OF INTRA-EMBRYONIC MESODERM AND COELOM

(a) FORMATION OF PARAXIAL, INTERMEDIATE AND LATERAL PLATE MESODERM

1. cardiogenic area.
2. intermediate mesoderm.
3. lateral plate mesoderm.
4. paraxial mesoderm.
5. notochord.
6. connecting stalk.

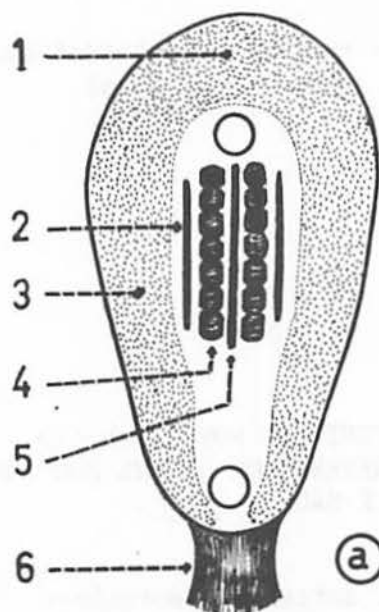
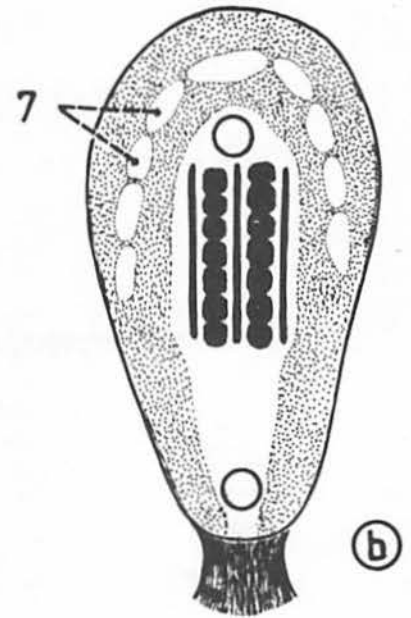


Fig.(36): DIFFERENTIATION OF INTRA-EMBRYONIC MESODERM AND COELOM (continued)

(b) EARLY STAGE OF INTRA-EMBRYONIC COELOM

7. separate clefts in lateral plate mesoderm.



(c) ADVANCED STAGE OF INTRA-EMBRYONIC COELOM

8. septum transversum.
9. pericardial cavity.
10. primitive pleural cavity.
11. coelomic duct (primitive peritoneal cavity).
12. communication between intra-embryonic coelom and extra-embryonic coelom.

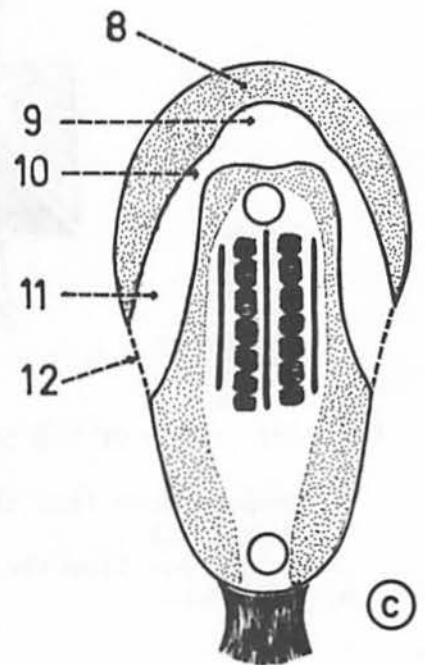




Fig.(37): SEGMENTATION OF PARAXIAL MESODERM INTO 42-44 SOMITES

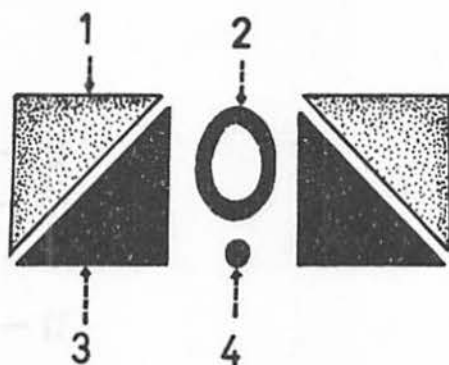


Fig.(38): PARTS OF THE SOMITE

1. dermomyotome from the dorsolateral part (forms skin and muscles).
2. neural tube.
3. sclerotome from the ventromedial part (forms bones and cartilage).
4. notochord.

ANTERO-POSTERIOR FOLDING OF THE DISC

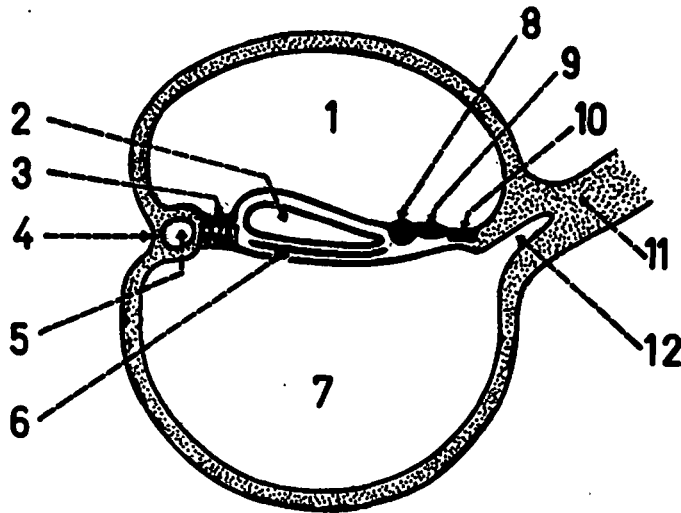


Fig.(39): L.S. IN THE MIDLINE OF THE DISC (BEFORE FOLDING)
(at the plane 1-1 in fig. 42)

1. amniotic cavity.
2. neural tube.
3. buccopharyngeal membrane.
4. septum transversum (most cranial).
5. pericardial cavity.
6. notochord.
7. secondary yolk sac.
8. primitive node.
9. primitive streak.
10. cloacal membrane.
11. connecting stalk (most caudal).
12. allantois.

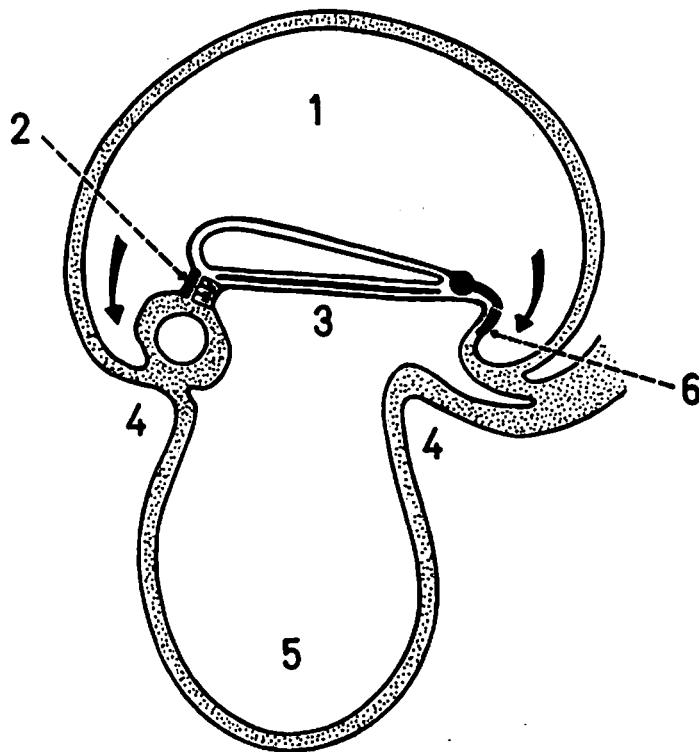


Fig.(40): EARLY ANTERO-POSTERIOR FOLDING
(formation of the head and tail folds)

1. amniotic cavity.
2. buccopharyngeal membrane (most cranial).
3. gut.
4. extra-embryonic coelom.
5. yolk sac.
6. cloacal membrane (most caudal).

N.B.: The arrows show the direction of pressure on the disc due to expansion of the amniotic cavity. The head fold is formed at the cranial end of the disc, while the tail fold is formed at its caudal end.

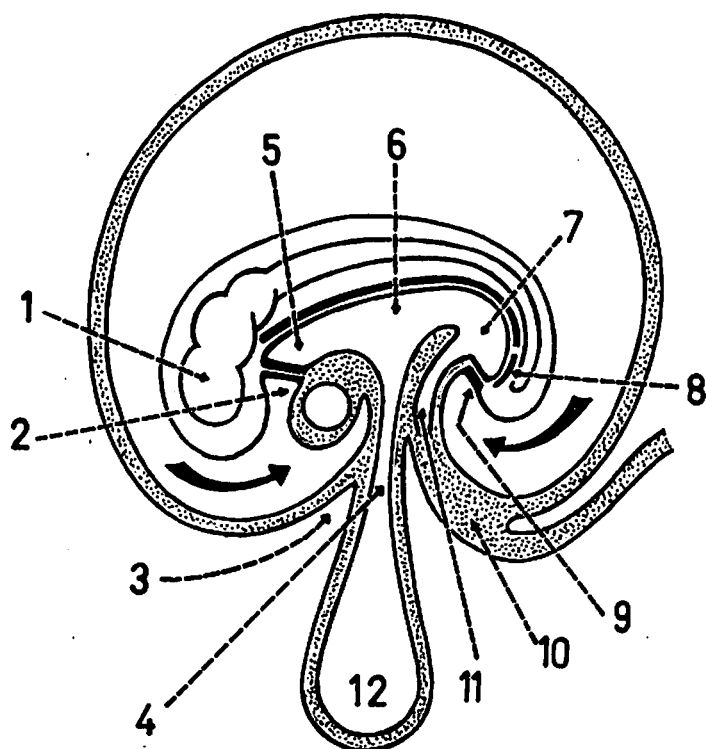


Fig.(41): ADVANCED ANTERO-POSTERIOR FOLDING

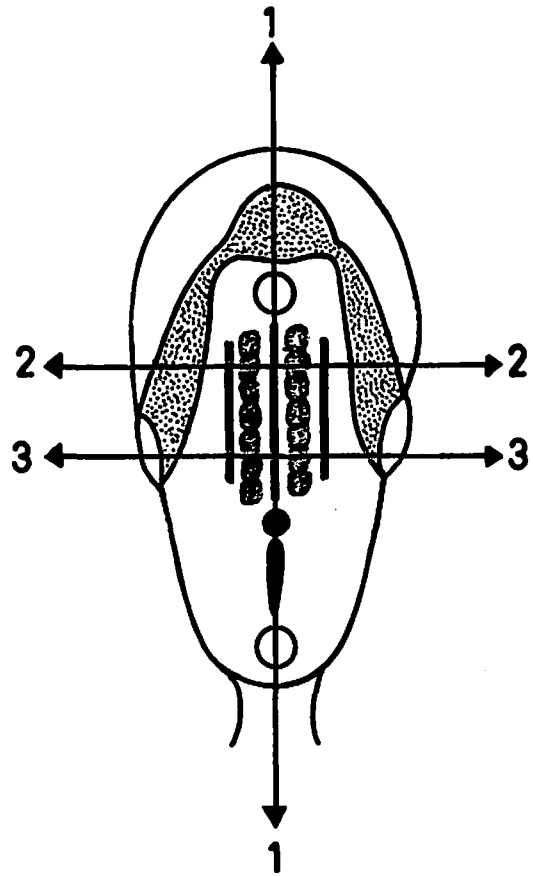
1. forebrain vesicle (forming a bulge).
2. stomodeum (it is the primitive mouth bounded by the forebrain bulge, pericardial bulge and buccopharyngeal membrane).
3. extra-embryonic coelom.
4. vitello-intestinal duct (between the gut and yolk sac).
5. foregut (the part in the head fold).
6. midgut (the part opposite the vitello-intestinal duct).
7. hindgut (the part in the tail fold).
8. primitive streak.
9. cloacal membrane (ventral in position).
10. connecting stalk (cranial to the cloacal membrane).
11. allantois.
12. definitive yolk sac (the part of yolk sac left after formation of the gut).

N.B.: The pericardial cavity is caudal to the buccopharyngeal membrane, and the septum transversum is the most caudal structure in the head fold.

LATERAL FOLDING OF THE DISC

Fig.(42): EMBRYONIC DISC SHOWING THE PLANES OF SECTIONING

- * Plane (1-1): L.S. in the midline.
- * Plane (2-2): T.S. at the level just cranial to the communication between the intra-embryonic coelom and the extra-embryonic coelom.
- * Plane (3-3): at the communication between the intra-embryonic and extra-embryonic coeloms.

Fig.(43): T.S. IN EMBRYONIC DISC
TAKEN AT THE PLANE (2-2) IN
FIG.(42)

- 1. amniotic cavity.
- 2. neural tube.
- 3. intermediate mesoderm.
- 4. coelomic duct in lateral plate mesoderm.
- 5. paraxial mesoderm (somites).
- 6. notochord.
- 7. yolk sac.

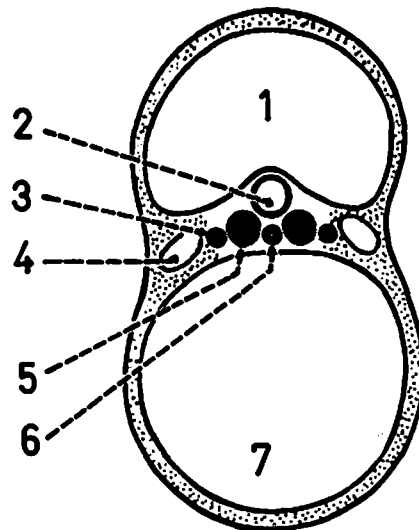


Fig. (44) : EARLY LATERAL FOLDING AT THE PLANE (2-2) IN FIG. (42)

1. amniotic cavity .
2. coelomic duct (primitive peritoneal cavity).
3. yolk sac.

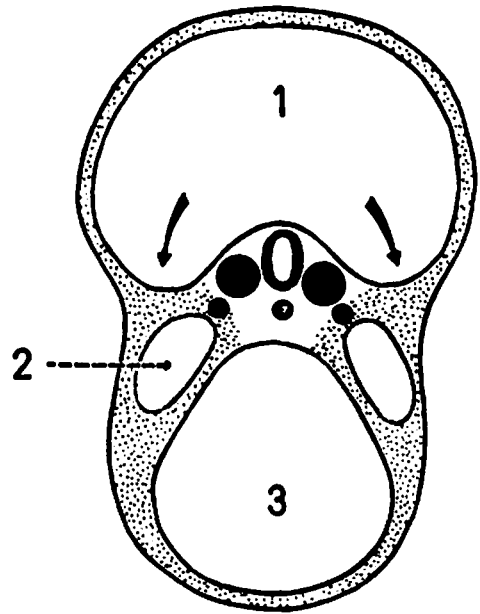


Fig. (45) : LATE LATERAL FOLDING AT THE PLANE (2-2) IN FIG. (42)

1. expanding amniotic cavity
2. expanding coelomic duct
3. foregut

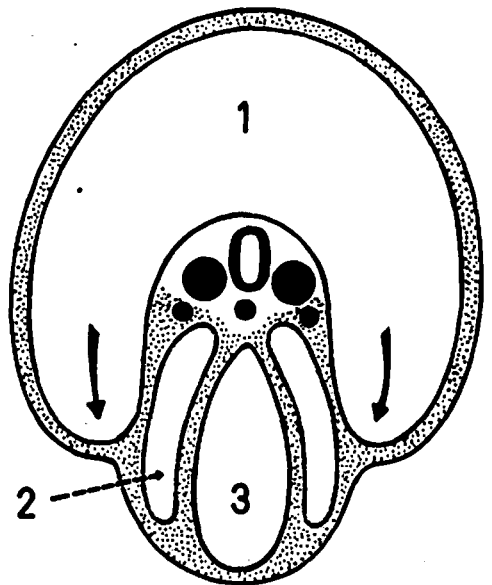


Fig.(46): LATE LATERAL FOLDING WITH
FORMATION OF DORSAL AND
VENTRAL MESENTERIES

1. amniotic cavity.
2. dorsal mesentery.
3. foregut (region of the stomach).
4. side of peritoneal cavity.
5. ventral mesentery.

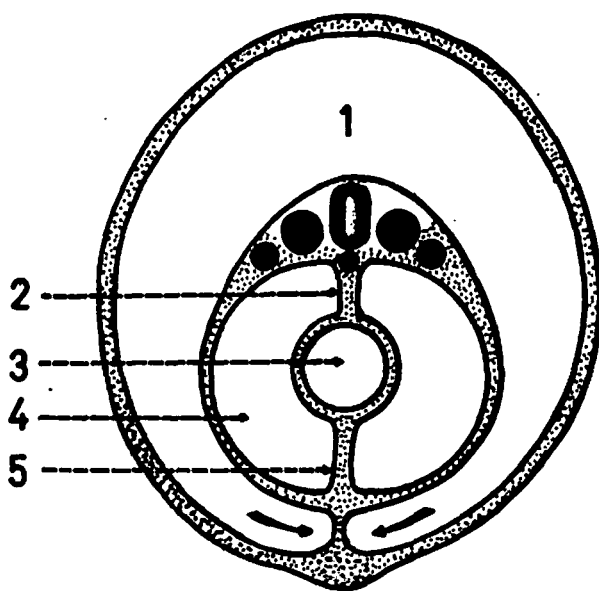
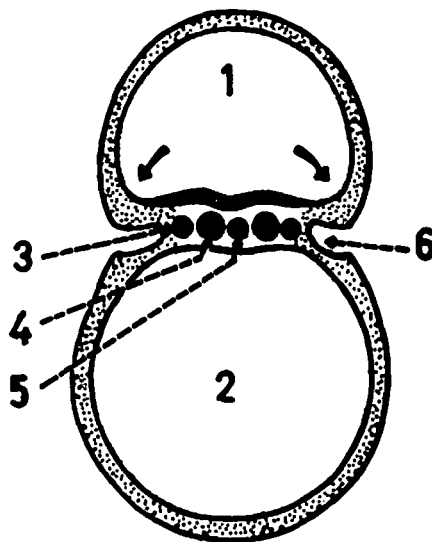
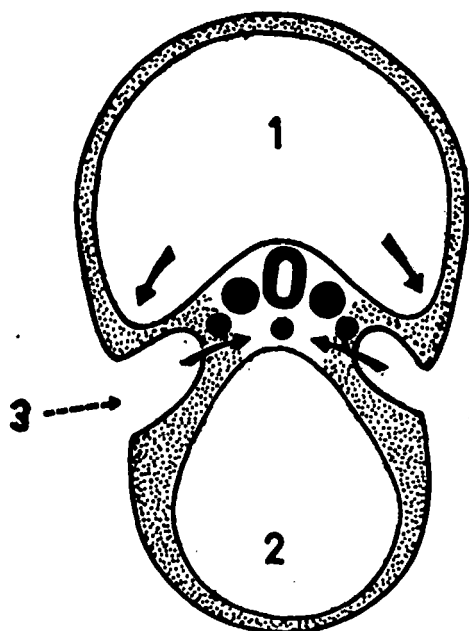


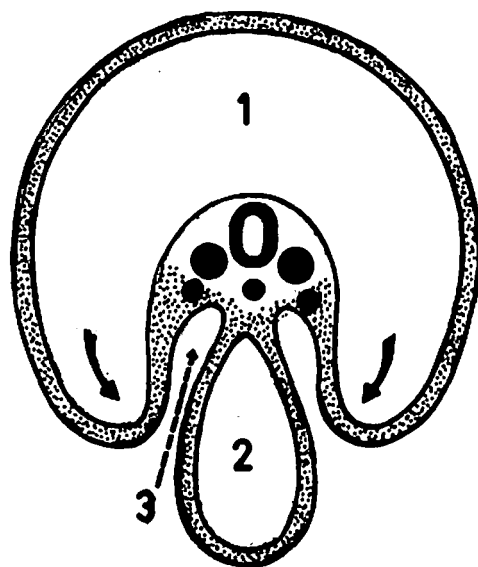
Fig.(47): T.S. IN EMBRYONIC DISC
BEFORE FOLDING, TAKEN AT
THE PLANE (3-3) IN FIG.(42)

1. amniotic cavity.
2. yolk sac.
3. intermediate mesoderm.
4. paraxial mesoderm.
5. notochord.
6. coelomic duct opening laterally.





(a)



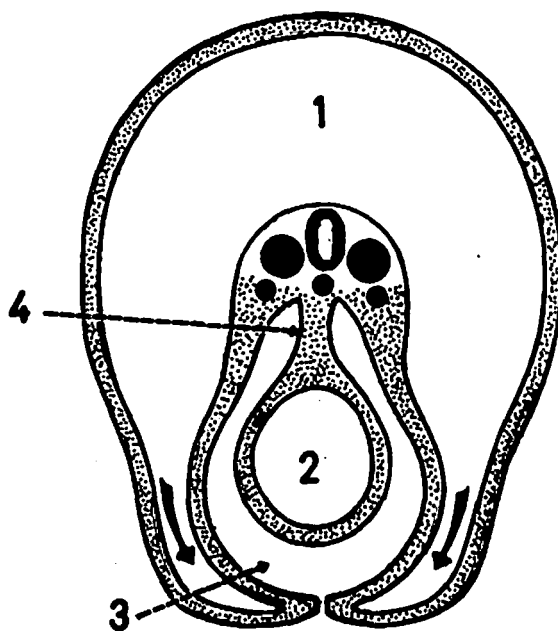
(b)

Fig.(48): LATERAL FOLDING AT THE PLANE
(3-3) IN FIG.(42)

(a) Early stage:
note the medial expansion
of coelomic ducts to come
behind the future gut.

(b) Progressive lateral
folding.

(c) Advanced lateral folding:
note that the gut (midgut
or hind gut) is suspended
in the peritoneal cavity
by a dorsal mesentery.



(c)

1. amniotic cavity.
2. yolk sac, then becomes gut.
3. intra-embryonic coelom at the site
where it communicates with the
extra-embryonic coelom.
4. dorsal mesentery.

UMBILICAL CORD

Fig.(49): FORMATION OF VITELLO-INTESTINAL DUCT

1. amniotic cavity.
2. peritoneal cavity.
3. edge of the lateral fold.
4. gut.
5. vitello-intestinal duct.
6. definitive yolk sac.

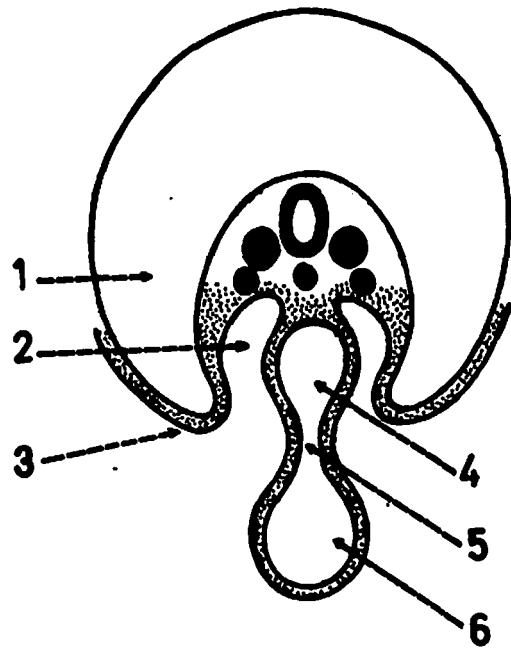


Fig.(50): FULLY-FORMED UMBILICAL CORD

1. amniotic cavity.
2. gut.
3. vitello-intestinal duct.
4. vitelline vessels (from yolk sac).
5. definitive yolk sac.
6. umbilical vessels (from placenta).
7. primitive streak.
8. allantois (future urachus).
9. remnant of extra-embryonic coelom.
10. amnion (outer coat of the cord).
11. placenta.

N.B.: The mesoderm of the cord is transformed into Wharton's jelly.

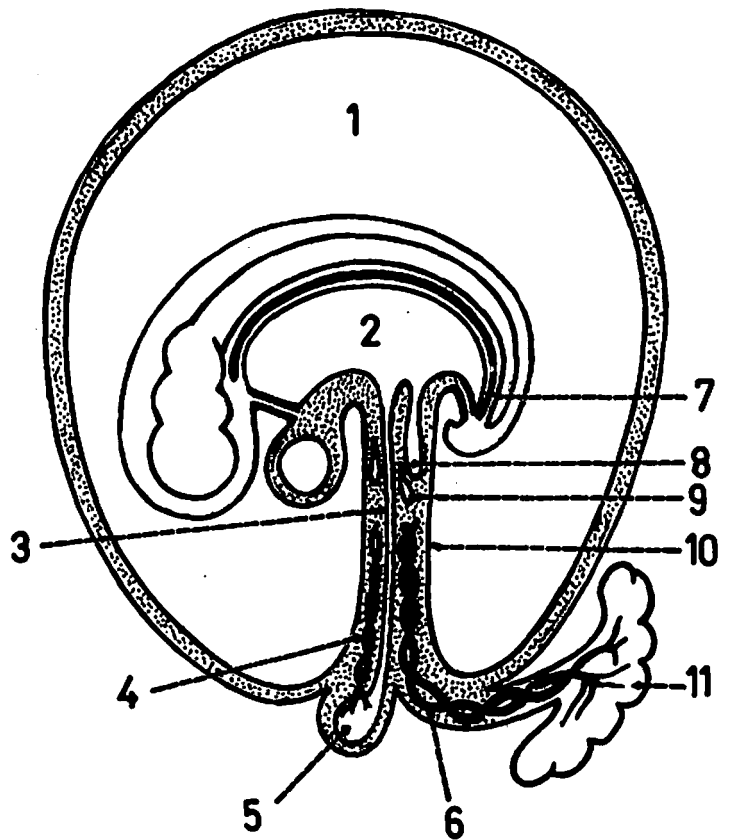
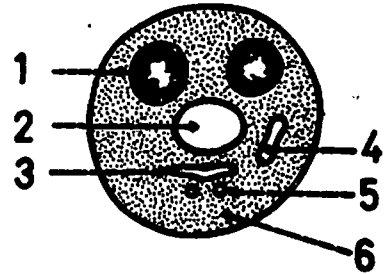


Fig.(51): T.S. IN UMBILICAL CORD

1. umbilical artery (double).
2. left umbilical vein.
3. vitello-intestinal duct (later on degenerates).
4. allantois (future urachus).
5. vitelline vessels.
6. Wharton's jelly.



N.B.: The right umbilical vein completely degenerates.

Fig.(52): PHYSIOLOGICAL UMBILICAL HERNIA OF THE FOETUS

1. herniated loop of midgut.
2. degenerating vitello-intestinal duct.
3. definitive yolk sac.
4. proximal part of umbilical cord.

N.B.: This hernia is transitory and occurs in the clefts of extra-embryonic coelom present in the proximal part of the umbilical cord.

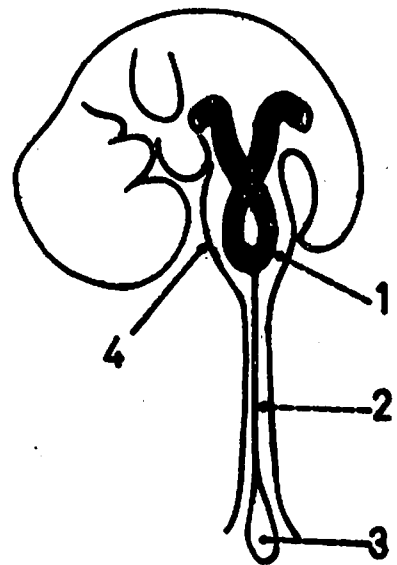


Fig.(53): TRUE KNOT OF THE CORD



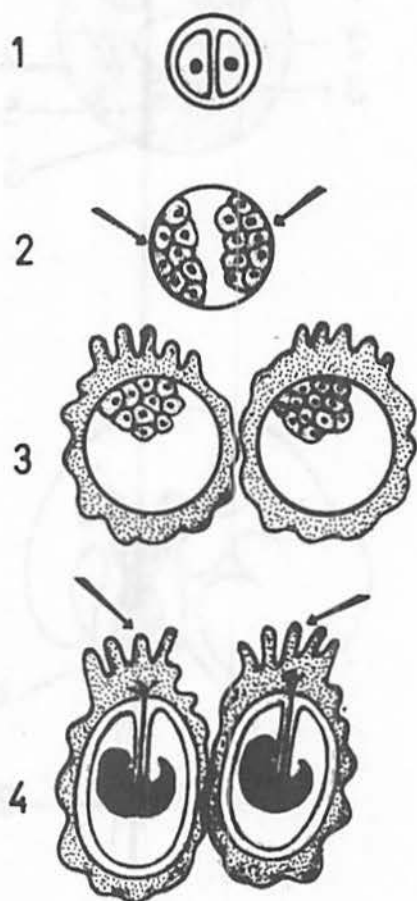


Fig.(54): MONOZYGOTIC TWINS AT
THE TWO-CELL STAGE

1. zygote of 2-cell stage (2 blastomeres).
2. two morulae (one morula from each blastomere).
3. two separate blastocysts implanting separately.
4. two chorionic vesicles with 2 placentae.

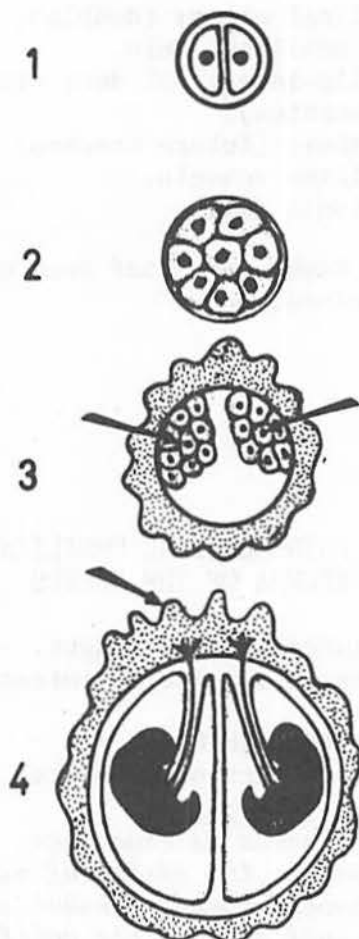


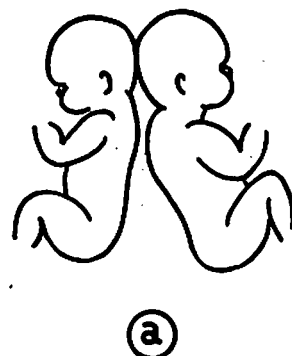
Fig.(55): MONOZYGOTIC TWINS AT
THE INNER CELL MASS

1. zygote of 2-cell stage.
2. one morula.
3. one blastocyst with 2 inner cell masses.
4. one chorionic vesicle with one placenta.

Fig.(56): CONJOINED TWINS (DOUBLE MONSTERS)

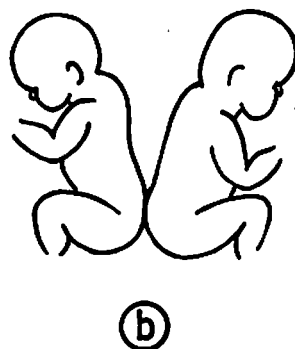
(a) CRANIOPAGUS

The twins are united at the head region (pagus = united).



(b) PYGOPAGUS

The twins are united at the pelvic region.



(c) THORACOPAGUS

The twins are united at the ventral wall of the trunk.



N.B.: Conjoined twins takes place at the stage of the embryonic disc where the primitive streak splits but incompletely.

PART (II)

SPECIAL EMBRYOLOGY

CARDIOVASCULAR SYSTEM

HEART TUBE

Fig.(57): SINGLE HEART TUBE IN THE PERICARDIAL CAVITY (AFTER FOLDING)

1. pericardial cavity enclosing the heart tube.
2. dorsal aorta (one on each side).
3. foregut.
4. septum transversum.

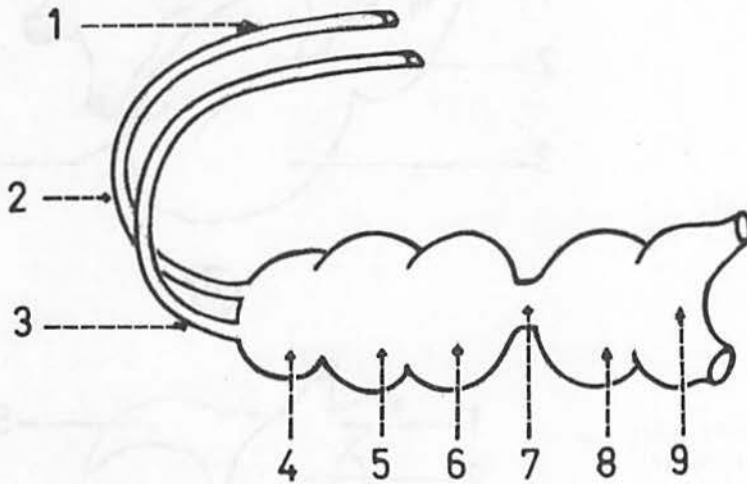
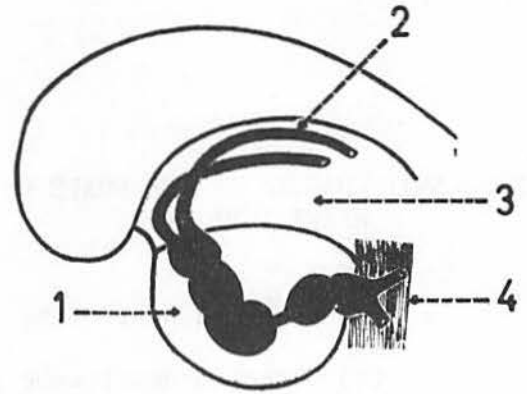


Fig.(58): CHAMBERS OF THE HEART TUBE

1. dorsal aorta.
2. connecting segment (between dorsal aorta and ventral aorta).
3. ventral aorta.
4. truncus arteriosus (most cranial).
5. bulbus cordis.
6. primitive ventricle.
7. atrio-ventricular canal.
8. primitive atrium.
9. sinus venosus (with two horns; most caudal).

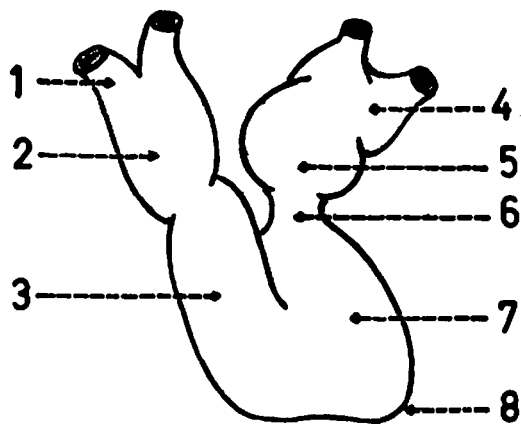
Fig.(59): CHANGES IN THE SHAPE OF THE HEART TUBE

(a) U-shaped heart tube

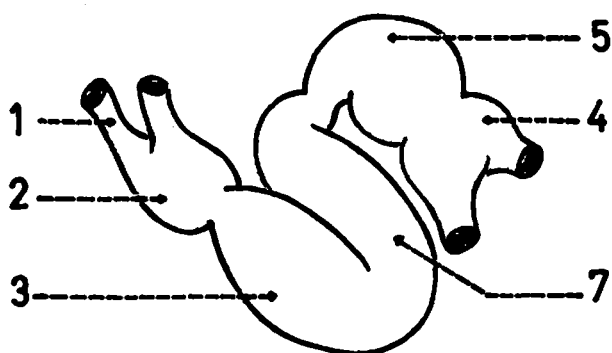
(b) S-shaped heart tube

(c) Dorsal migration of the primitive atrium

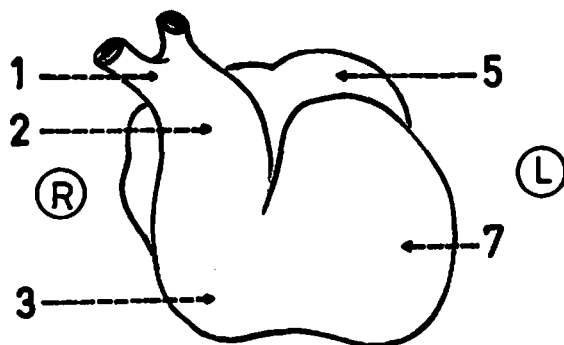
1. ventral aorta.
2. truncus arteriosus.
3. bulbus cordis.
4. sinus venosus.
5. primitive atrium.
6. atrio-ventricular canal.
7. primitive ventricle.
8. future apex of heart.



(a)



(b)



(c)

N.B.:

Note that (a) is an illustration of the early stage of the heart tube having cranial and caudal limbs, while (c) is an advanced stage of the heart as seen from in front.

SINUS VENOSUS

Fig.(60): SINUS VENOSUS WITH TWO EQUAL HORNS

1. primitive atrium.
2. sinus venosus.
3. right common cardinal vein (duct of Cuvier).
4. right umbilical vein.
5. right vitelline vein.
6. right horn of sinus venosus.
7. left horn of sinus venosus.

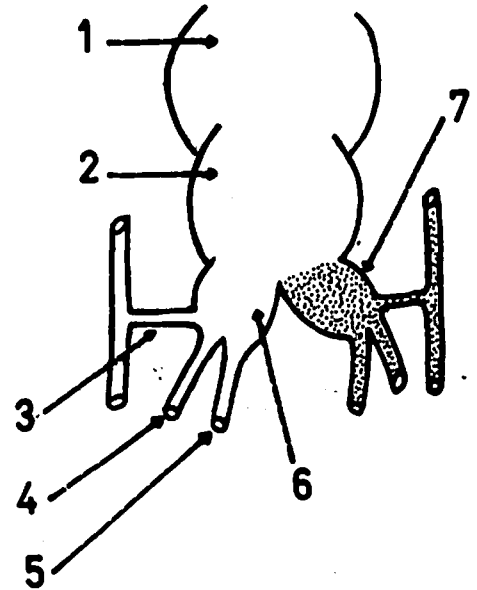


Fig.(61): SINUS VENOSUS WITH ATTENUATED LEFT HORN

1. right horn (dilated).
2. left horn (attenuated).
3. sinu-atrial orifice with right and left venous valves (marked by arrows).

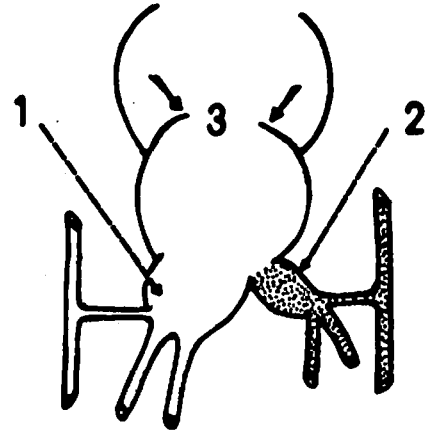


Fig.(62): SINU-ATRIAL ORIFICE AS SEEN FROM THE CAVITY OF THE PRIMITIVE ATRIUM

1. fused right and left venous valves (septum spurium).
2. middle part of right venous valve (forms crista terminalis).
3. sinu-atrial orifice.
4. lower part of right venous valve (forms valve of inferior vena cava).
5. left venous valve (disappears by fusion with the interatrial septum).
6. primitive atrium.
7. atrio-ventricular cushion in the A-V canal.

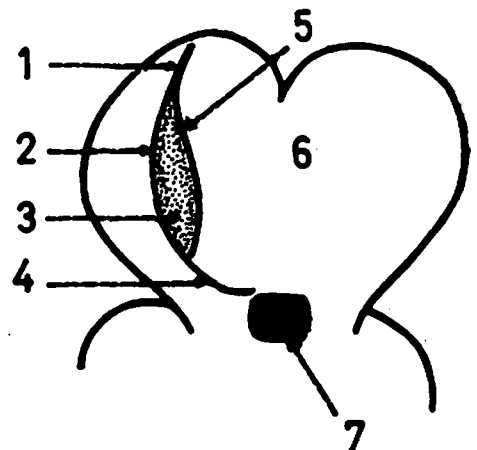
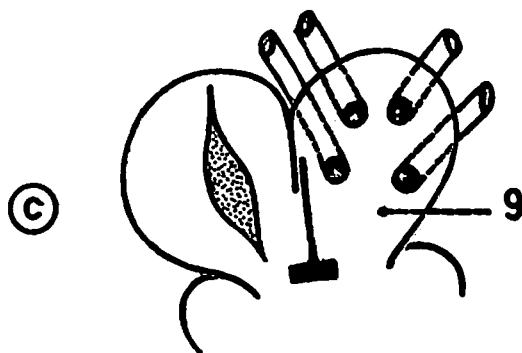
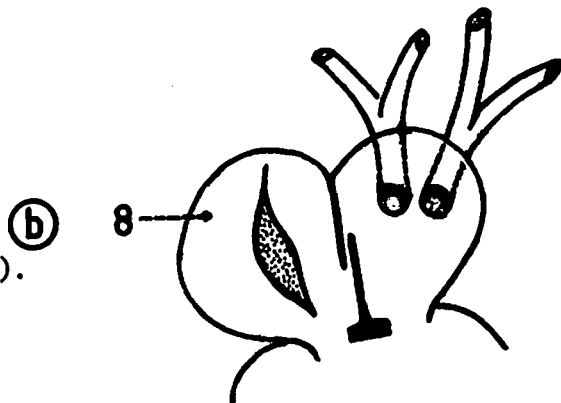
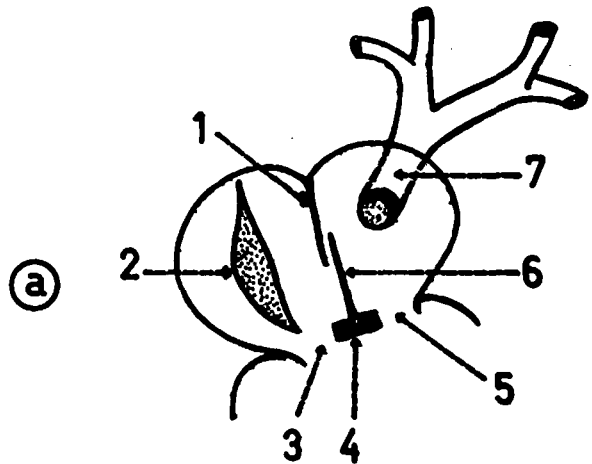


Fig.(63): DEVELOPMENT OF LEFT ATRIUM

- (a) Opening of one common pulmonary vein
- (b) Openings of two pulmonary veins
- (c) Openings of four pulmonary veins



1. septum secundum.
2. sinu-atrial orifice opening into the right atrium.
3. right A-V canal.
4. A-V cushions (septum intermedium).
5. left A-V canal.
6. septum primum.
7. common pulmonary vein.
8. right atrium.
9. left atrium.

INTERATRIAL SEPTUM

Fig.(64): FORMATION OF ATRIO-VENTRICULAR CUSHIONS

- (a) A-V canal
- (b) Ventral and dorsal A-V endocardial cushions
- (c) Fusion of the two cushions to form the septum intermedium between the right and left A-V canals

- 1. wall of A-V canal showing endocardial tissue.
- 2. single A-V canal.
- 3. dorsal A-V cushion.
- 4. ventral A-V cushion.
- 5. right A-V canal.
- 6. fused endocardial cushions (septum intermedium).

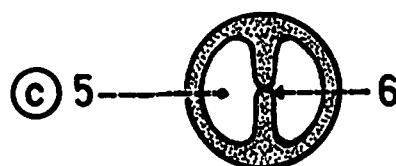
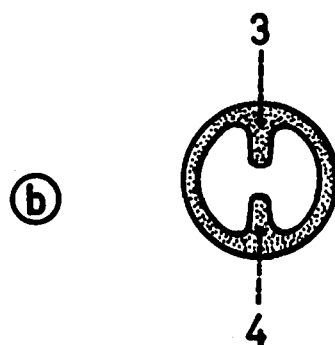
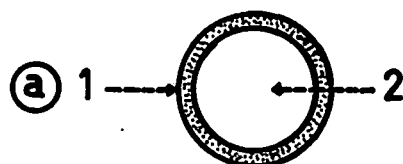


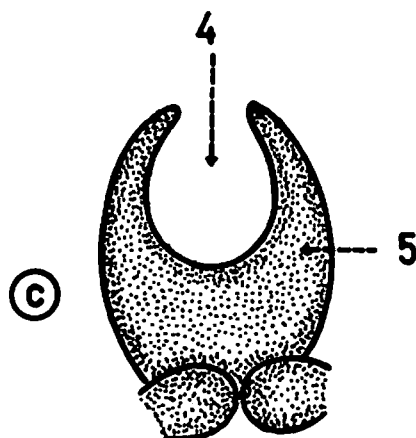
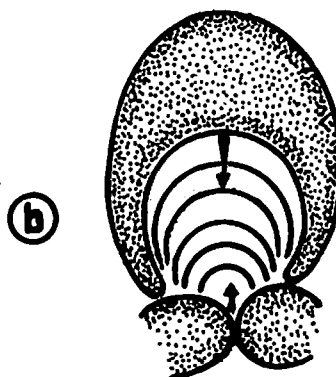
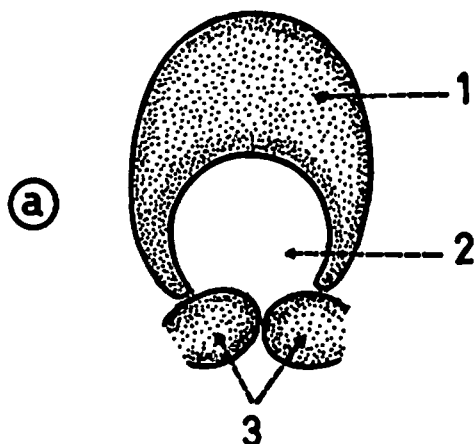
Fig.(65): FORMATION OF SEPTUM PRIMUM

(a) Early stage with ostium primum

(b) Closure of the ostium primum

(c) Late stage with ostium secundum

1. septum primum.
2. ostium primum enclosed by the horns of the septum primum.
3. fused endocardial cushions in the A-V canal (septum intermedium).
4. ostium secundum (degeneration of the cranial end of the septum primum).
5. septum primum with the two horns directed cranially (reverse of the early stage).



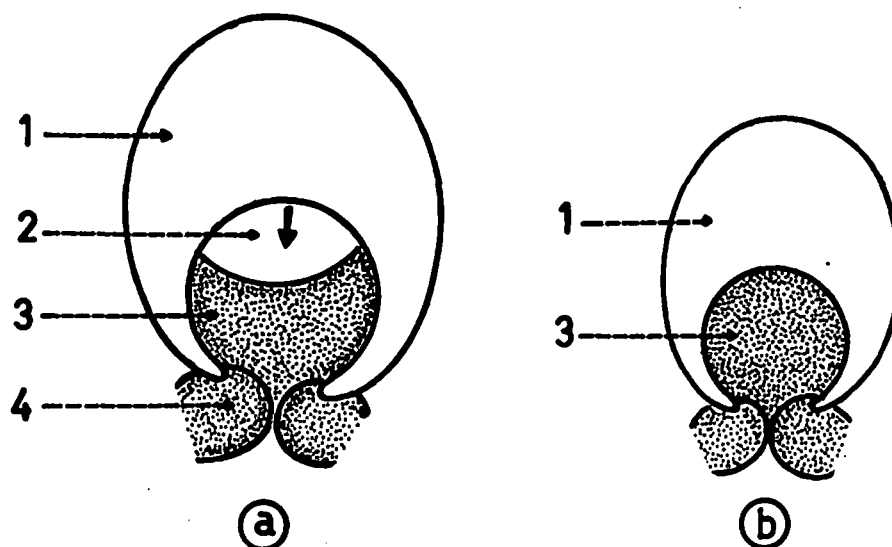


Fig.(66): FORMATION OF SEPTUM SECUNDUM

(a) Early stage: formation of foramen ovale

(b) Late stage: closure of foramen ovale

1. septum secundum (formed to the right of septum primum; its horns form the limbus fossa ovalis of the adult interatrial septum).
2. foramen ovale (between the caudal border of septum secundum and cranial border of septum primum; it closes by caudal growth of septum secundum).
3. septum primum (forms the fossa ovalis of the adult interatrial septum).
4. fused A-V cushions.

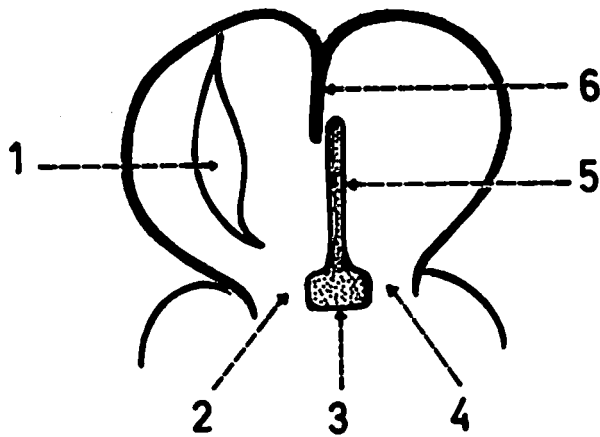


Fig.(67): INTERATRIAL SEPTUM

1. sinu-atrial orifice.
2. right A-V canal.
3. fused A-V cushions (septum intermedium).
4. left A-V canal.
5. septum primum.
6. septum secundum.

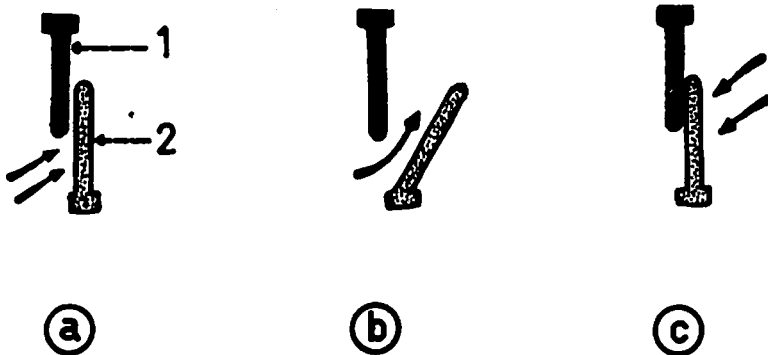


Fig.(68): BLOOD FLOW THROUGH INTERATRIAL SEPTUM

- (a&b) Before birth (flow from right to left):
 1. septum secundum; 2. septum primum (the blood passes through the foramen ovale).
- (c) After birth (no flow):
 the septum primum is pressed against the septum secundum thus closing the foramen ovale.

INTERVENTRICULAR SEPTUM

Fig.(69): MUSCULAR PART OF INTER-
VENTRICULAR (I.V.) SEPTUM

- (a) Early stage:
starting cavitation of
right and left ventricles.
- (b) Progressive cavitation of
the two ventricles and
appearance of muscular
part of the I.V. septum
- (c) Well-developed muscular
part of the I.V. septum

- 1. fused A-V cushions.
- 2. gap between the muscular I.V.
septum and the fused A-V cushions.
- 3. muscular I.V. septum.

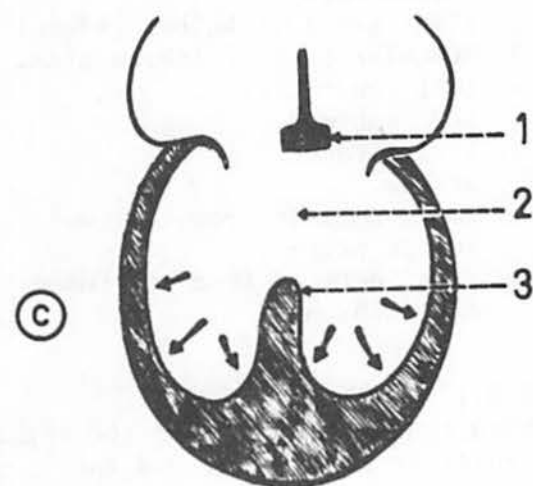
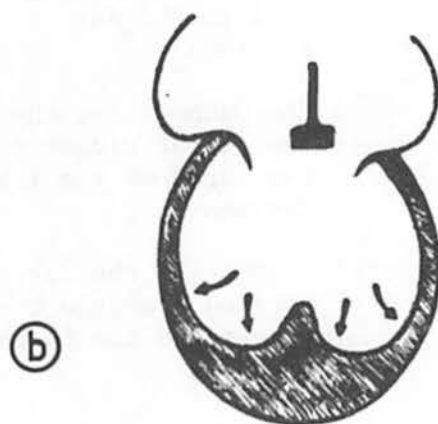
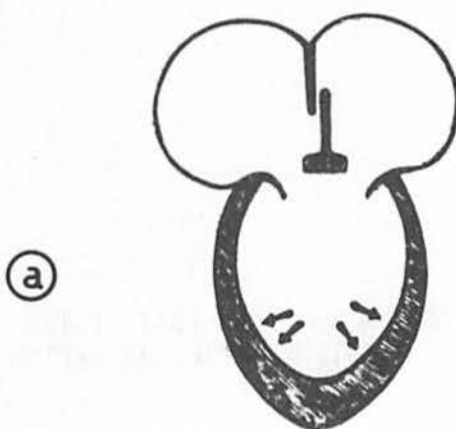


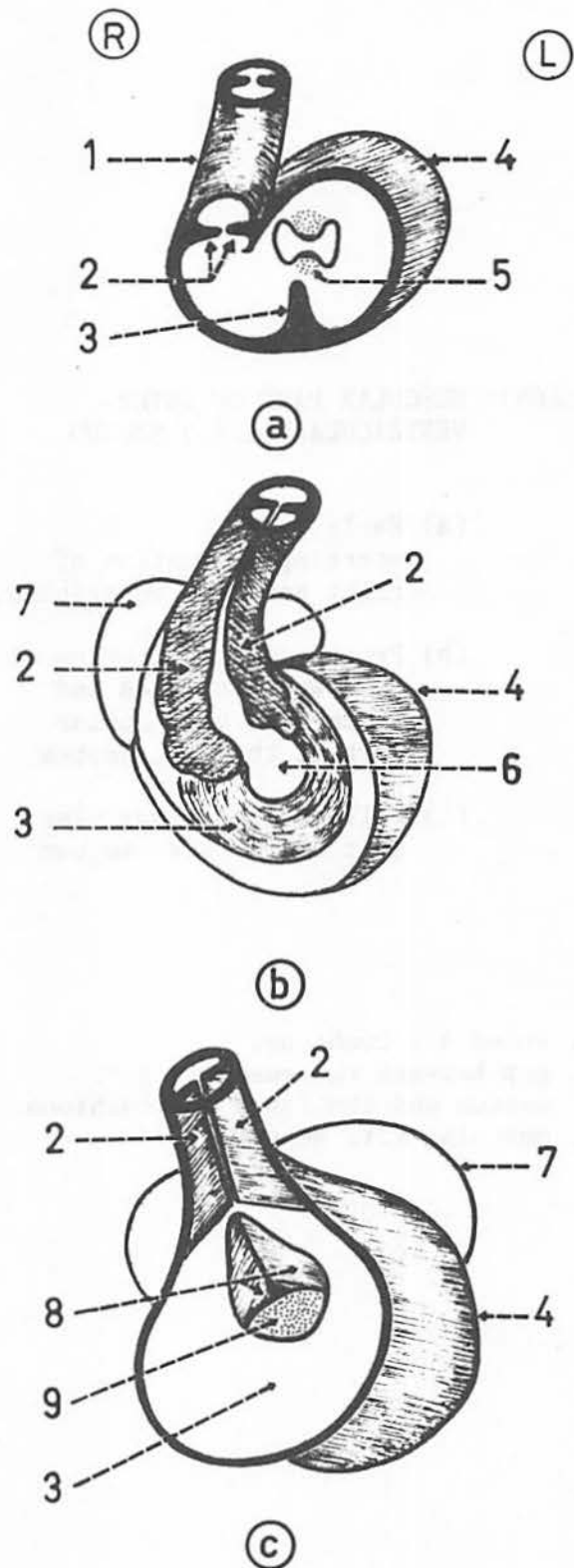
Fig.(70): MEMBRANOUS PART OF THE INTERVENTRICULAR SEPTUM

- (a) Components: right and left bulbar ridges as well as the A-V cushions
- (b) Encroachment of the two bulbar ridges on the edges of the I.V. foramen
- (c) Closure of the I.V. foramen from the two ridges and the fused cushions

1. bulbus cordis.
2. right and left bulbar ridges.
3. muscular part of I.V. septum.
4. left ventricle.
5. A-V cushions.
6. I.V. foramen.
7. atrium.
8. parts derived from the two bulbar ridges.
9. part derived from the fused A-V cushions.

N.B.:

Note that in (b) and (c) the right ventricle is removed, and the I.V. septum is seen from the right side.



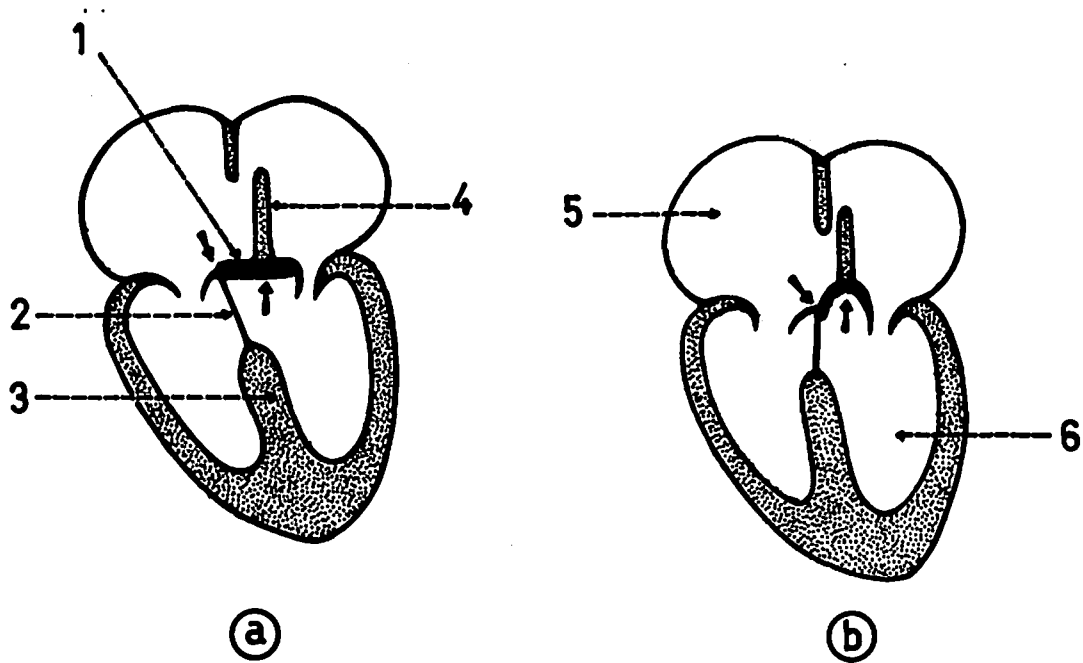


Fig.(71): RELATION OF THE INTERATRIAL AND INTERVENTRICULAR SEPTA TO THE FUSED A-V CUSHIONS

(a) Early stage (horizontal position of the cushions):
the I.A. septum is attached exactly at the midline of the cushions, while the I.V. septum is attached to the right of the midline.

(b) Advanced stage (vertical position of the cushions)

1. fused A-V cushions.
2. membranous I.V. septum.
3. muscular I.V. septum.
4. interatrial septum.
5. right atrium.
6. left ventricle.

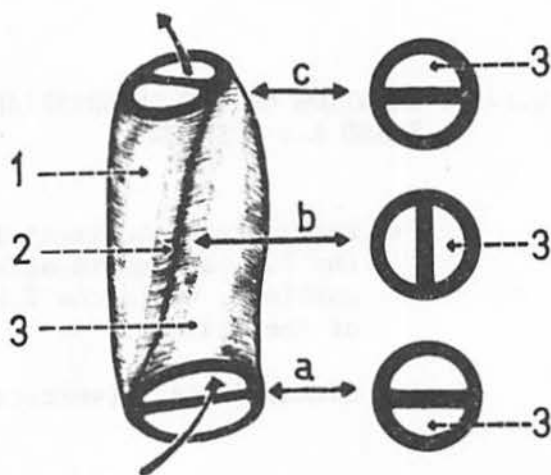
N.B.: The membranous part of interventricular septum in the adult separates the left ventricle from both the right ventricle and right atrium.

AORTICO-PULMONARY SEPTUM

Fig(72): AORTICO-PULMONARY SEPTUM
SHOWING SPIRAL FORMFig.(73): FORMATION OF THE SPIRAL
AORTICO-PULMONARY SEPTUM
IN THE TRUNCUS ARTERIOSUS

1. ascending aorta.
2. line of the aortico-pulmonary septum.
3. pulmonary trunk.

N.B.: In T.S. of truncus arteriosus at level (a) the septum runs transversely from side to side with the pulmonary trunk lying anteriorly. In T.S. at level (b) the septum becomes antero-posterior, while at level (c) the septum comes again transverse with the pulmonary trunk posterior.



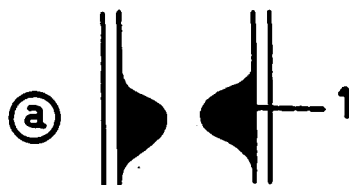
T.S.

CARDIAC VALVES

Fig.(74): MITRAL AND TRICUSPID VALVES

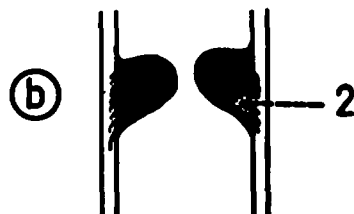
(a) Endocardial cushions in the A-V canal

1. endocardial cushion.



(b) The cushions are invaded by muscle tissue

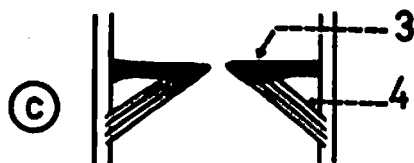
2. muscle tissue invading the base of the cushion.



(c) Differentiation of the cusps and papillary muscles

3. primitive cusp.

4. primitive papillary muscle (split off from the ventricular wall).



(d) Differentiation of the chordae tendineae from distal parts of papillary muscles

5. definitive cusp.

6. chordae tendineae.

7. definitive papillary muscle.

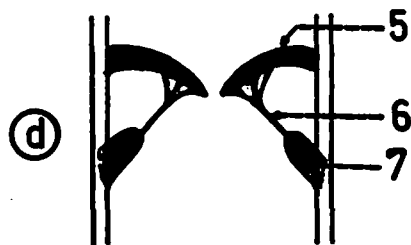


Fig.(75): SEMILUNAR VALVES
(AORTIC AND PULMONARY)

(a) Endocardial cushions at the aortic or pulmonary orifice

1. endocardial cushion.

(b) The cushions are hollowed out on their cranial aspect

2. cusp (hollowed out).

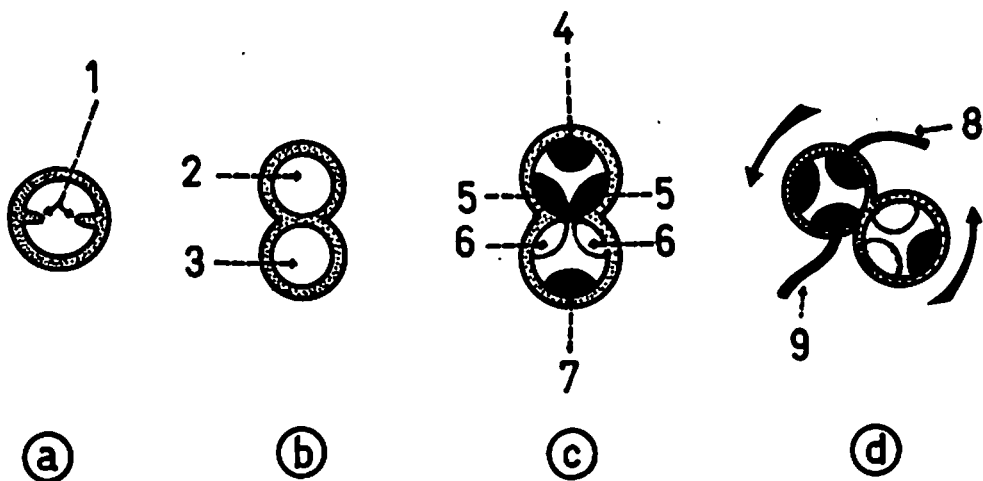
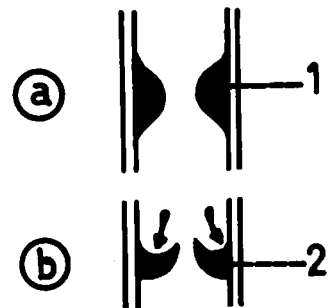


Fig.(76): AORTIC AND PULMONARY ORIFICES

(a) Right and left bulbar ridges at the distal end of bulbus cordis.

(b) Fusion of the bulbar ridges separates the pulmonary orifice (anterior) from the aortic orifice (posterior)

(c) Appearance of three endocardial cushions in each orifice

(d) Rotation of the two orifices to the left

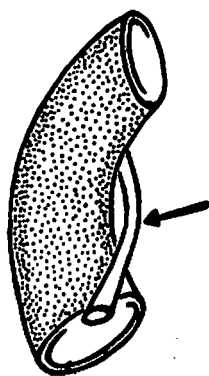
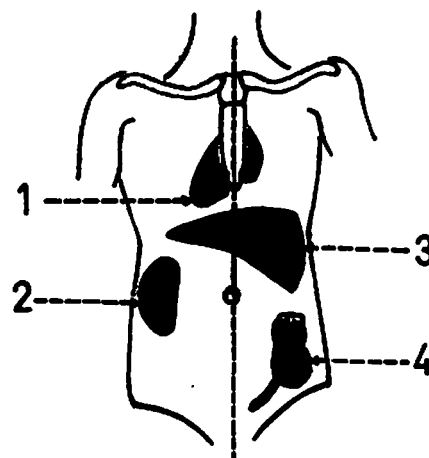
1. right and left bulbar ridges; 2. aortic orifice; 3. pulmonary orifice; 4. dorsal aortic cushion; 5. antero-lateral aortic cushions; 6. dorso-lateral pulmonary cushions; 7. ventral pulmonary cushion; 8. left coronary artery; 9. right coronary artery.

CONGENITAL ANOMALIES OF THE HEART

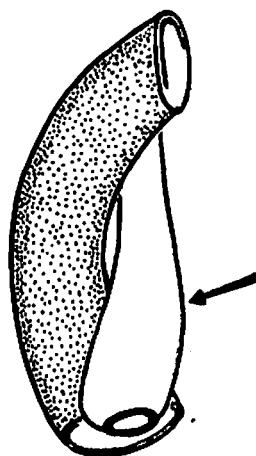
Fig.(77): SITUS INVERSUS

1. dextrocardia (the apex of the heart is directed to the right).
2. spleen (on the right side).
3. liver (on the left side).
4. caecum and appendix (on the left side).

N.B.: Situs inversus means transposition of the heart and abdominal viscera, i.e. those organs which lie on the right side come to lie on the left side, and vice versa.



(a)



(b)

Fig.(78): ANOMALIES OF THE PULMONARY TRUNK

- (a) Stenosis (narrowing) of the pulmonary trunk
- (b) Stenosis of the pulmonary orifice only

Fig.(79): OVERRIDING OF THE AORTA
ASSOCIATED WITH I.V. SEPTAL
DEFECT

The aortic orifice lies over the patent I.V. foramen, thus it receives blood from both ventricles. This anomaly is seen in Fallot's tetralogy and Eisenminger's complex

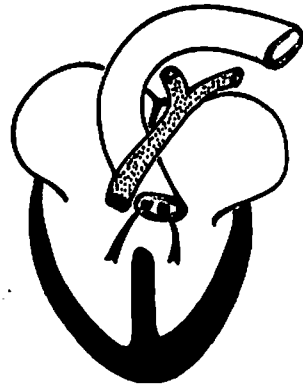
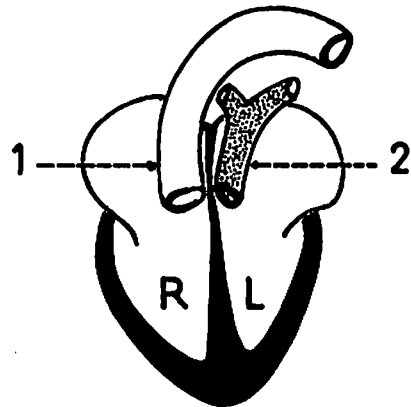


Fig.(80): TRANSPOSITION OF THE GREAT
VESSELS

1. ascending aorta.
2. pulmonary trunk.

The aorta arises from the right ventricle, while the pulmonary trunk arises from the left ventricle (due to reversed spiral arrangement of the aortico-pulmonary septum).



ARTERIES

AORTIC ARCHES

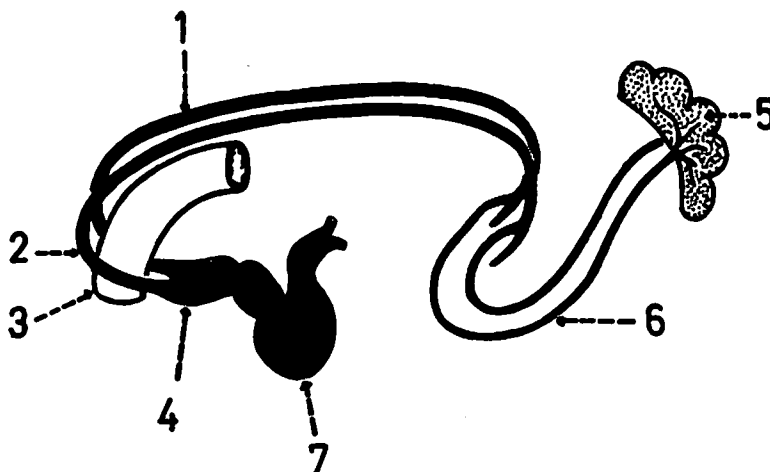


Fig.(81): DIFFERENTIATION OF THE TWO PRIMITIVE AORTAE

1. dorsal aorta (runs dorsal to the gut).
2. connecting segment (connects the dorsal aorta with the ventral aorta).
3. foregut (pharynx).
4. aortic sac (formed by fusion of the two ventral aortae).
5. placenta.
6. umbilical artery (caudal continuation of the dorsal aorta).
7. heart tube.

Fig.(82): FORMATION OF AORTIC ARCHES

1. 1st aortic arch (the connecting segment).
2. the two dorsal aortae (dorsal to the pharynx).
3. pharynx.
4. 6th aortic arch (the most caudal).
5. aortic sac (ventral to the pharynx and receives the arches of both sides).

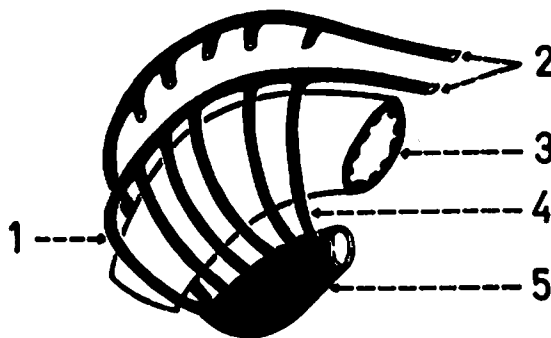


Fig.(83): AORTIC ARCHES
(ventral view)

1. 1st aortic arch (most cranial).
2. right dorsal aorta.
3. 6th aortic arch (most caudal).
4. aortic sac.
5. left dorsal aorta.

The aortic sac is continuous caudally with the truncus arteriosus.

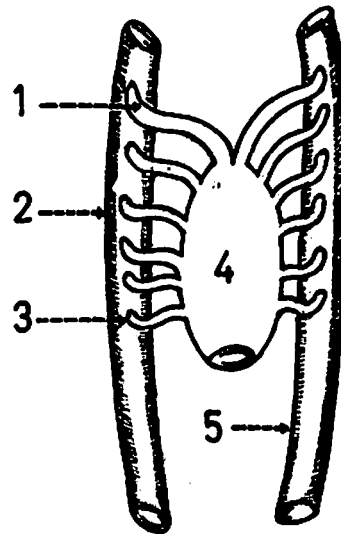


Fig.(84): DEGENERATION OF THE 1st, 2nd
AND 5th ARCHES

1. aortic sac (with two horns).
2. right dorsal aorta.
3. site of union of the two dorsal aortae to form one single dorsal aorta (extending from 4th thoracic to 4th lumbar segments).

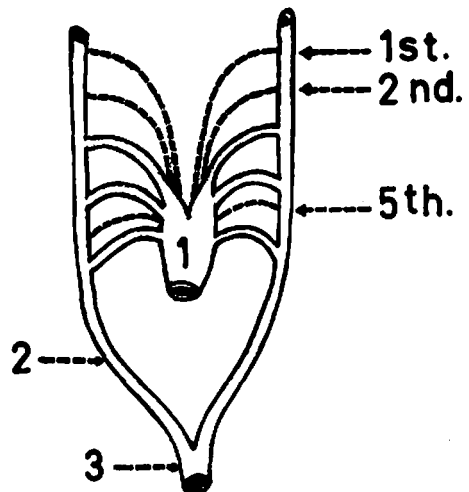


Fig.(85): DEGENERATION OF THE
DUCTUS CAROTICUS

1. degenerated ductus caroticus (the segment of the dorsal aorta between the 3rd and 4th arches).
2. 7th cervical intersegmental artery (forms a part of the subclavian artery).
3. lung bud (gets a pulmonary branch from the 6th arch).
4. right dorsal aorta.
5. union of the two dorsal aortae.

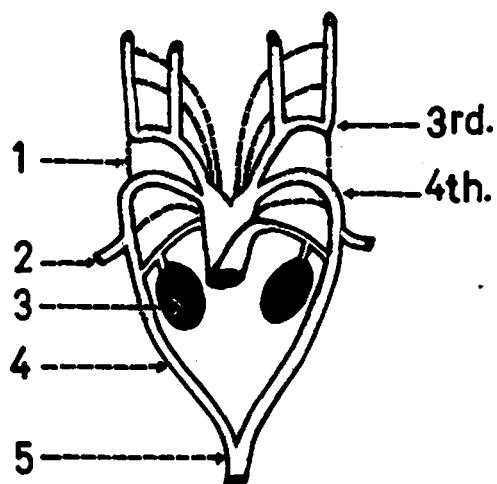
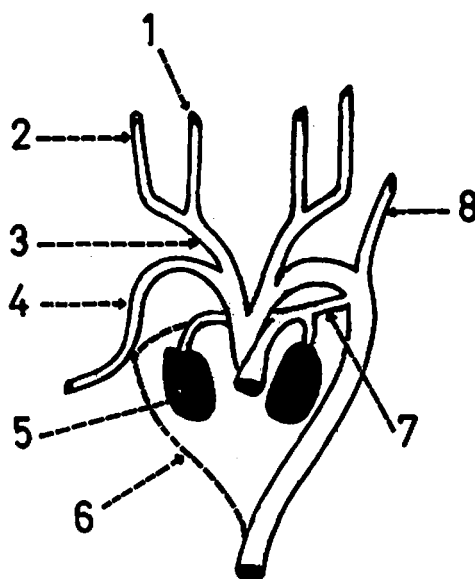


Fig.(86): CHANGES IN THE 3rd, 4th
AND 6th ARCHES

1. external carotid artery (a new branch from the 3rd arch).
2. internal carotid artery (partly from 3rd arch and partly from dorsal aorta).
3. common carotid artery (from 3rd arch).
4. right subclavian artery (from the right 4th arch). The left 4th arch forms a part from the arch of aorta.
5. lung bud.
6. degenerated right dorsal aorta.
7. ductus arteriosus (dorsal part of the left 6th arch). The dorsal part of the right 6th arch degenerates.
8. left subclavian artery (from the left 7th cervical intersegmental artery).



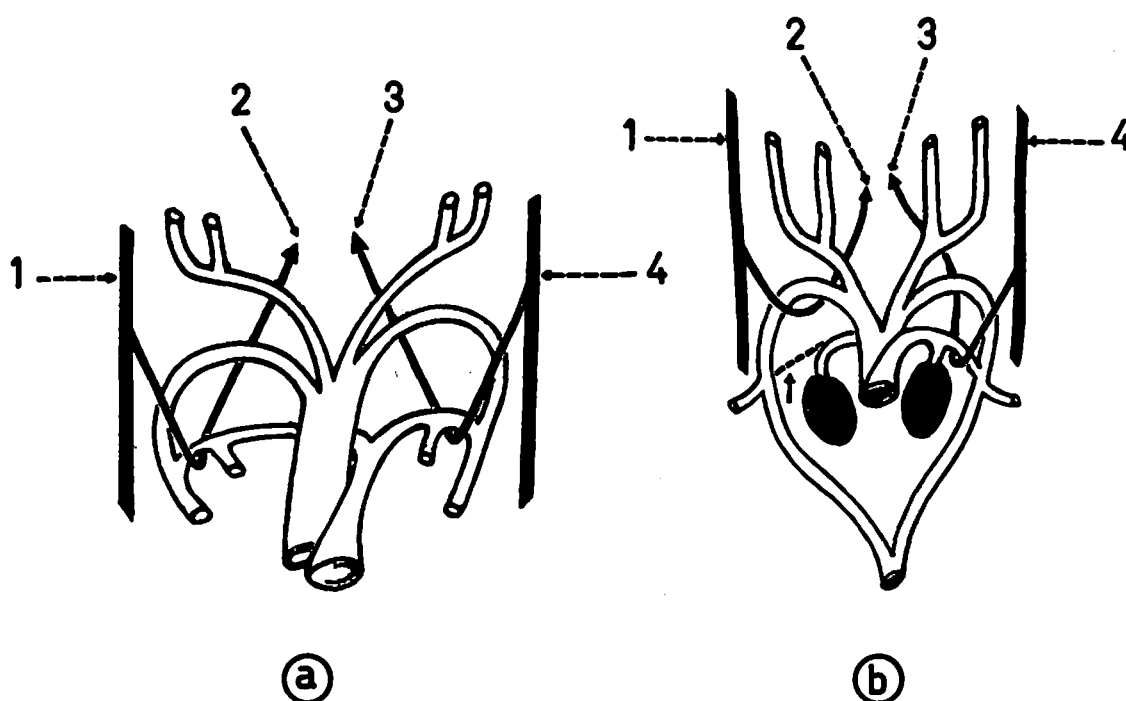


Fig.(87): COURSE OF RECURRENT LARYNGEAL NERVE IN RELATION TO THE 6th AND 4th ARCHES

(a) Early stage

(b) After degeneration of dorsal part of the right 6th arch

1. right vagus nerve.
2. right recurrent laryngeal nerve hooking round the dorsal part of the 6th arch in (a), but round the right 4th arch in (b).
3. left recurrent laryngeal nerve hooking round the dorsal part of the left 6th arch (ductus arteriosus).
4. left vagus nerve.

Fig.(88): DEVELOPMENT OF PULMONARY ARTERY

1. proximal part of the left pulmonary artery (from the ventral part of the 6th arch).
2. ductus arteriosus (from the dorsal part of the 6th arch).
3. distal part of the left pulmonary artery (this is a new branch developed from the 6th arch).
4. pulmonary trunk.

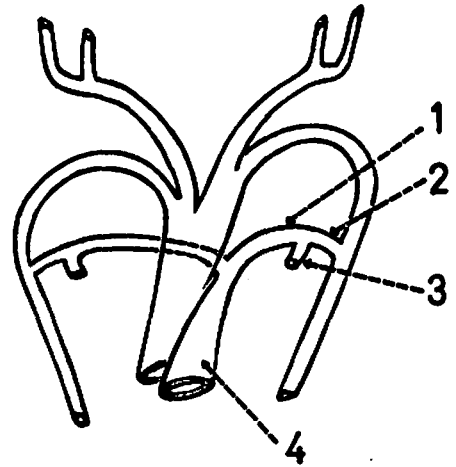


Fig.(89): ADULT PULMONARY ARTERIES

- 1: right pulmonary artery.
2. proximal part of left pulmonary artery.
3. ligamentum arteriosum (fibrosed ductus arteriosus).
4. distal part of left pulmonary artery.
5. pulmonary trunk.

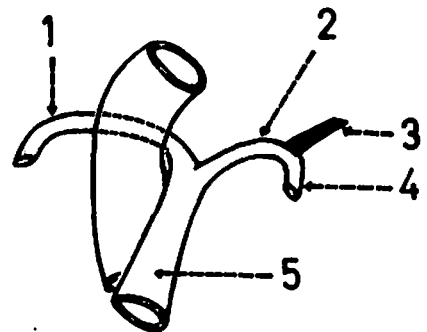


Fig.(90): DEVELOPMENT OF THE
ARCH OF AORTA
(from 4 segments)

1. segment derived from the stem of aortic sac.
2. right subclavian artery.
3. brachiocephalic artery.
4. segment derived from the left horn of aortic sac.
5. left common carotid artery.
6. segment derived from the left 4th arch.
7. left subclavian artery.
8. segment derived from the left dorsal aorta.
9. original site of the left 7th cervical intersegmental artery (before cranial migration).

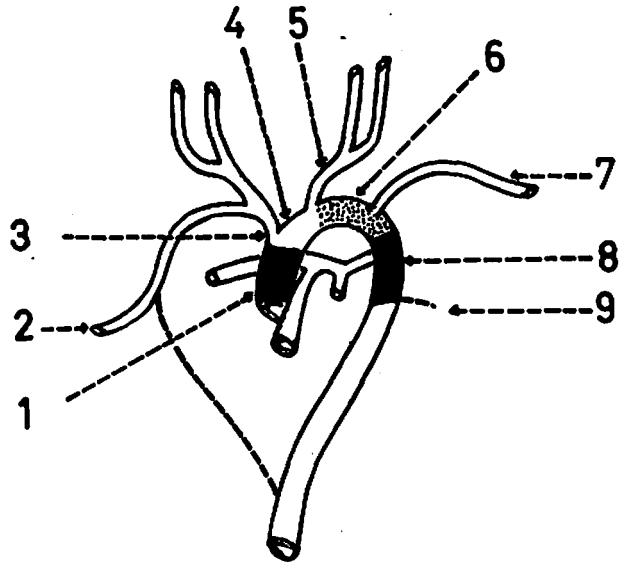
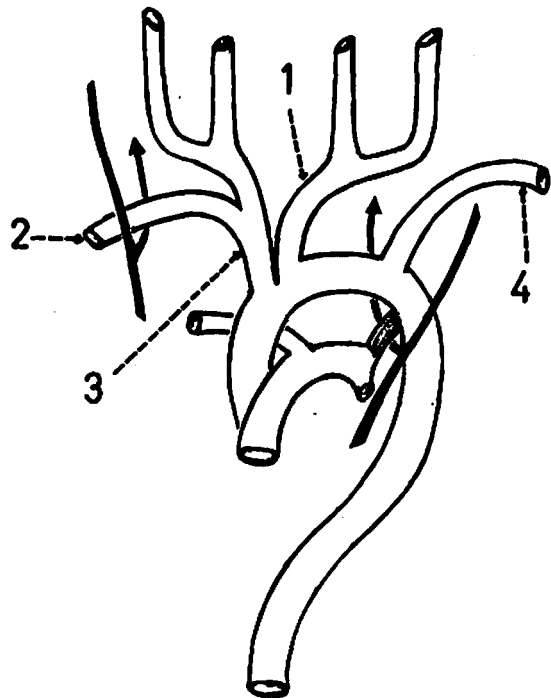


Fig.(91): ADULT ARRANGEMENT OF
THE GREAT VESSELS OF
THE HEART

1. left common carotid artery.
2. right subclavian artery.
3. brachiocephalic artery.
4. left subclavian artery.



ANOMALIES OF THE AORTIC ARCHES

Fig.(92): ABNORMAL RIGHT
SUBCLAVIAN ARTERY

1. abnormal right subclavian artery (arises from the descending aorta and crosses the midline behind the oesophagus).
2. oesophagus.
3. descending aorta.

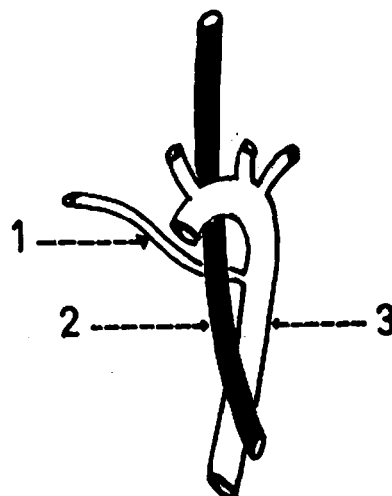
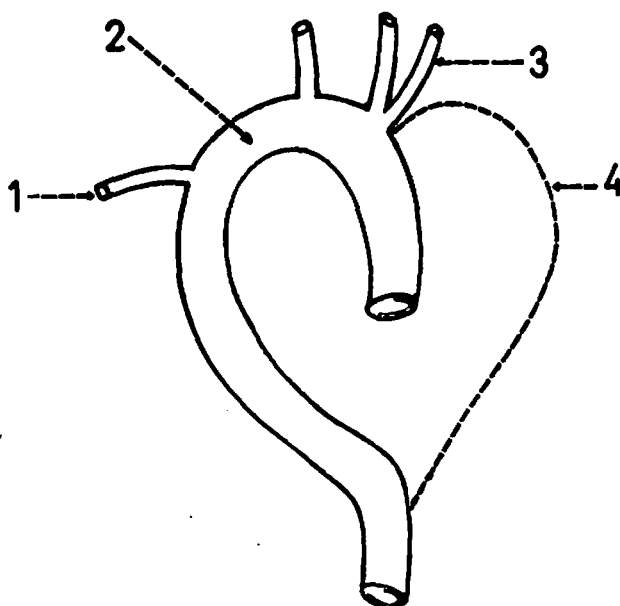


Fig.(93): ABNORMAL ARCH OF AORTA
(directed to the right)

1. right subclavian artery.
2. right arch of aorta.
3. left subclavian and left common carotid arising from a common stem.
4. degenerated left dorsal aorta.



DORSAL AORTA

Fig.(94): COARCTATION OF THE AORTA

(narrowing of the aorta at the aortic isthmus, marked by arrow)

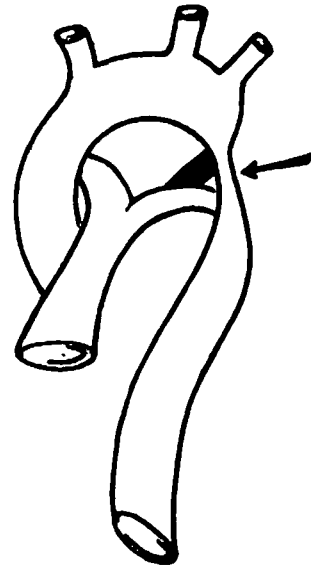


Fig.(95): BRANCHES OF DORSAL AORTA

1. intersegmental arteries (posterior intercostals).
2. superior mesenteric artery.
3. intersegmental arteries (lumbar).
4. inferior phrenic artery.
5. coeliac artery.
6. inferior mesenteric artery.
7. terminal branch (umbilical artery).

N.B.: The dorsal aorta gives off branches from its ventral aspect (ventral splanchnic), from its lateral aspect (lateral splanchnic) and from its dorso-lateral aspect (intersegmental).

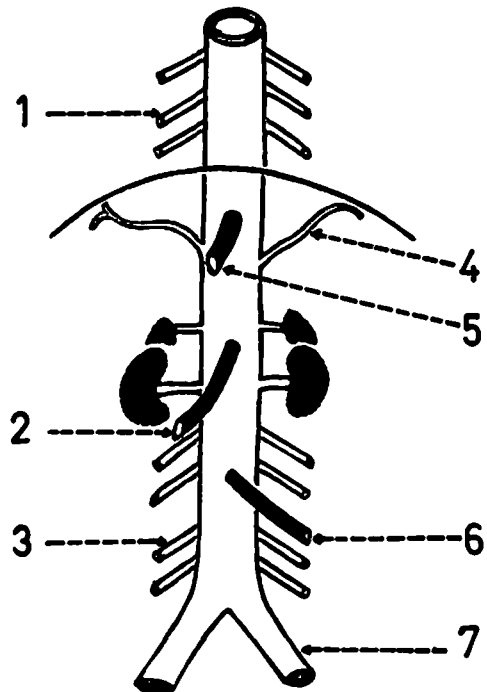


Fig.(96): LONGITUDINAL ANASTOMOSIS
BETWEEN INTERSEGMENTAL ARTERIES

1. dorsal longitudinal anastomosis.
2. dorsal aorta.
3. intersegmental artery.
4. ventral longitudinal anastomosis.

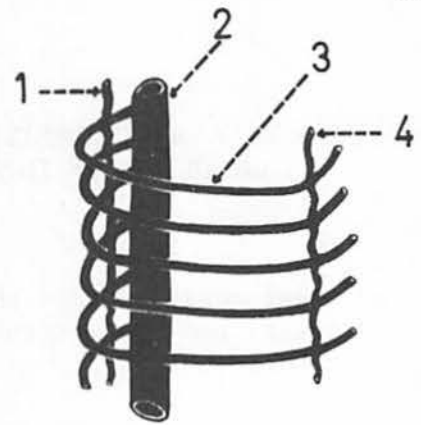


Fig.(97): LONGITUDINAL ANASTOMOSIS
BETWEEN THE SPLANCHNIC ARTERIES

1. longitudinal anastomosis ventral to the gut.
2. longitudinal anastomosis dorsal to the gut.

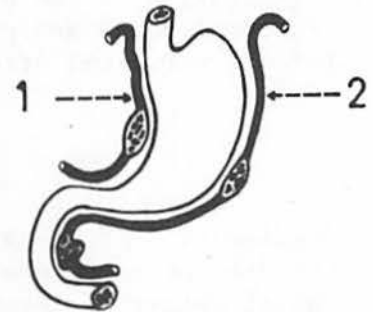


Fig.(98): DORSAL LONGITUDINAL
ANASTOMOSIS BETWEEN INTER-
SEGMENTAL ARTERIES

1. post-transverse anastomosis (posterior to the transverse processes).
2. transverse process of vertebra.
3. post-costal anastomosis (behind the costal elements of transverse processes in the neck and is represented by the vertebral artery).
4. costal element of transverse process of cervical vertebra.
5. pre-costal anastomosis (in front of the costal elements of transverse processes).
6. body of cervical vertebra.

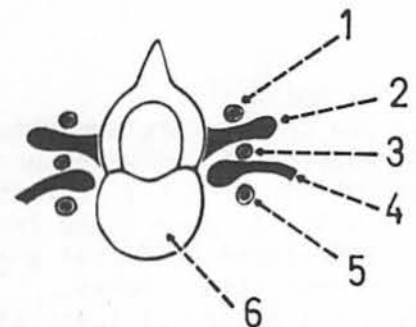
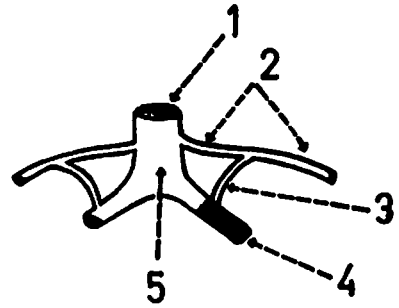
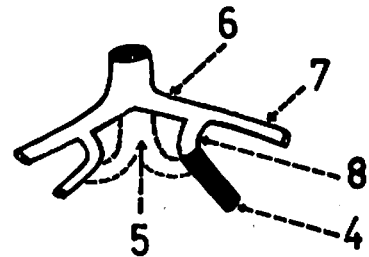


Fig.(99): FATE OF THE UMBILICAL ARTERY
AND ORIGIN OF ILIAC ARTERIES

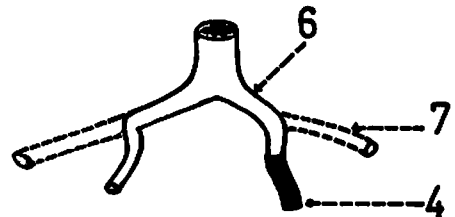
- (a) Anastomosis between the umbilical artery and 5th intersegmental artery (a)



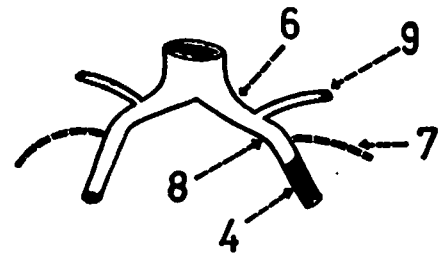
- (b) Degeneration of the caudal part of dorsal aorta and proximal part of umbilical artery (b)



- (c) Degeneration of distal part of the 5th intersegmental artery (axial artery of lower limb); its proximal part forms the common iliac artery (c)



- (d) Appearance of external iliac artery as a new branch from the common iliac artery (d)



1. dorsal aorta.
2. 5th lumbar intersegmental artery.
3. anastomosis between the 5th intersegmental and umbilical arteries.
4. umbilical artery (terminal branch of the primitive aorta). In the adult it becomes the lateral umbilical ligament.
5. caudal end of dorsal aorta.
6. common iliac artery.
7. axial artery of lower limb (degenerates).
8. internal iliac artery (derived from the anastomosis).
9. external iliac artery and its continuation which is the femoral artery.

ARTERIES OF THE LIMBS

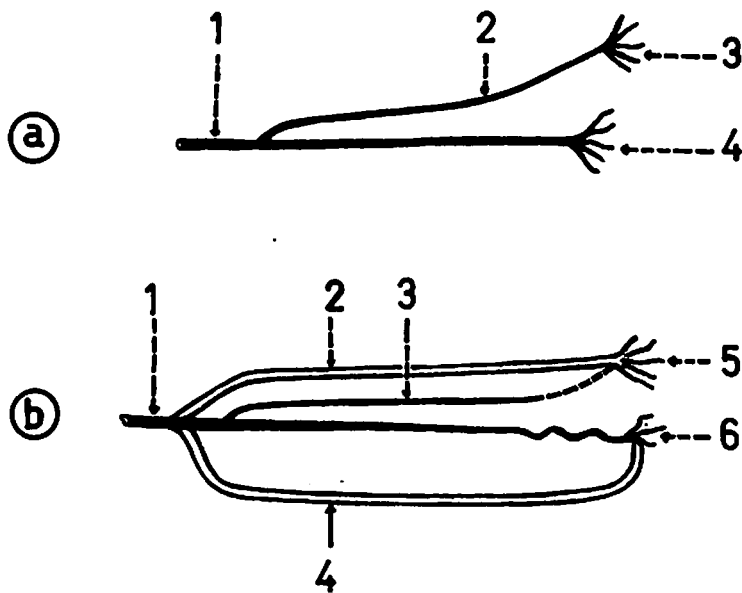


Fig.(100): ARTERIES OF THE UPPER LIMB

(a) Early stage

1. the axial artery (derived from 7th cervical intersegmental artery).
2. median artery.
3. superficial plexus.
4. deep plexus.

(b) Advanced stage

1. brachial artery.
2. ulnar artery (a new branch which joins the superficial arch).
3. median artery (shrinks).
4. radial artery (a new branch which joins the deep arch).
5. superficial palmar arch.
6. deep palmar arch.

N.B.: The axial artery is represented by the axillary, brachial and anterior interosseous arteries.

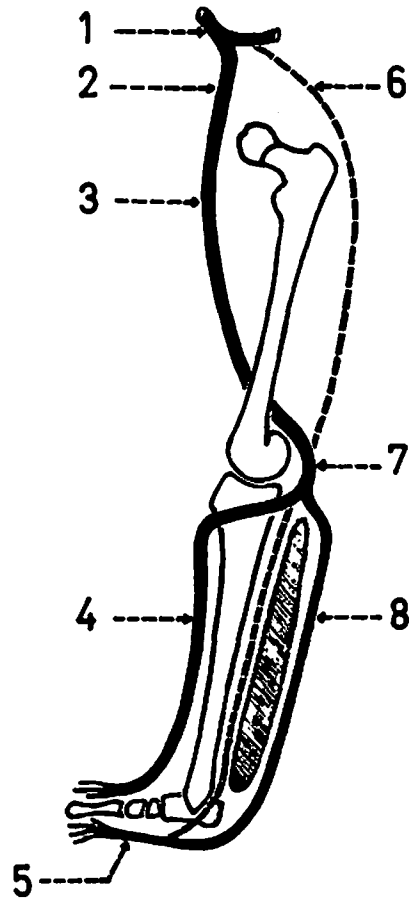


Fig.(101): ARTERIES OF THE LOWER LIMB

1. Common iliac artery.
2. external iliac artery.
3. femoral artery.
4. anterior tibial artery.
5. plantar arteries.
6. the axial artery in the back of thigh (degenerated).
7. popliteal artery.
8. posterior tibial artery.

N.B.: The axial artery is represented by the longitudinal anastomosis in the back of the thigh and by the peroneal artery in the back of the leg.

Fig.(102): THE THREE MAIN GROUPS OF FOETAL VEINS

1. cardinal veins (draining the tissues of the embryo).
2. umbilical veins (draining the placenta).
3. vitelline veins (draining the yolk sac; vitellus=yolk sac).
4. yolk sac.
5. placenta.
6. embryo.

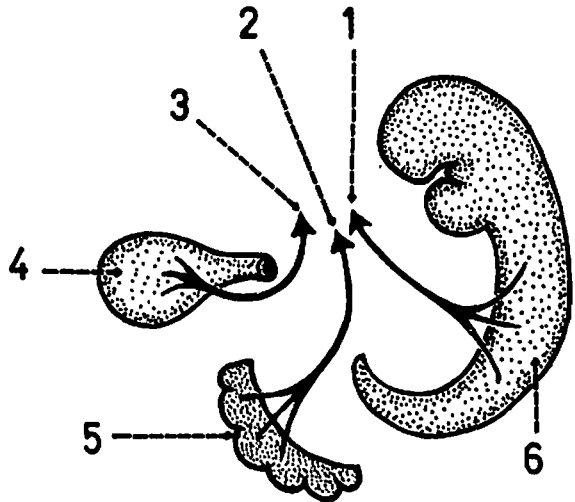


Fig.(103): EARLY STAGE OF VITELLINE AND UMBILICAL VEINS

1. sinus venosus.
2. septum transversum.
3. right umbilical vein.
4. right vitelline vein.
5. gut (duodenum).
6. left vitelline vein.
7. left umbilical vein.

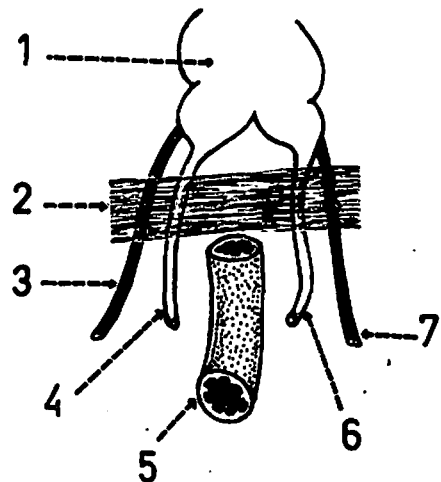


Fig.(104): EARLY STAGE OF PORTAL VEIN
(8-shaped arrangement of
vitelline veins)

1. sinus venosus.
2. septum transversum.
3. degenerated right umbilical vein.
4. right vitelline vein (the only one of all vitelline and umbilical veins which persists up to the sinus venosus).
5. gut (duodenum).
6. left vitelline vein (anastomosing with the right vitelline vein by two ventral and one dorsal anastomosis forming 8-shaped arrangement).
7. left umbilical vein.

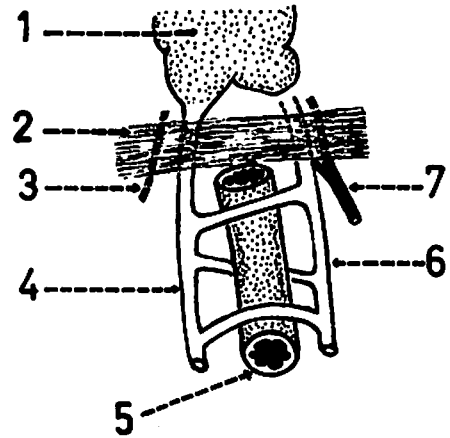
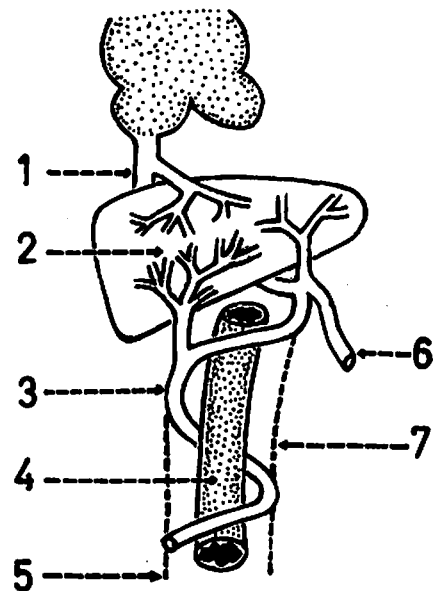


Fig.(105): ADVANCED STAGE OF PORTAL VEIN
(S-shaped)

1. cranial end of right vitelline vein (forms the cranial segment of I.V.C. called hepato-cardiac channel).
2. liver showing plexus of veins.
3. portal vein (dividing into right and left branches).
4. duodenum (with the portal vein forming S-shape around it).
5. degenerated part of right vitelline vein.
6. left umbilical vein (the right umbilical vein completely disappears).
7. degenerated part of left vitelline vein



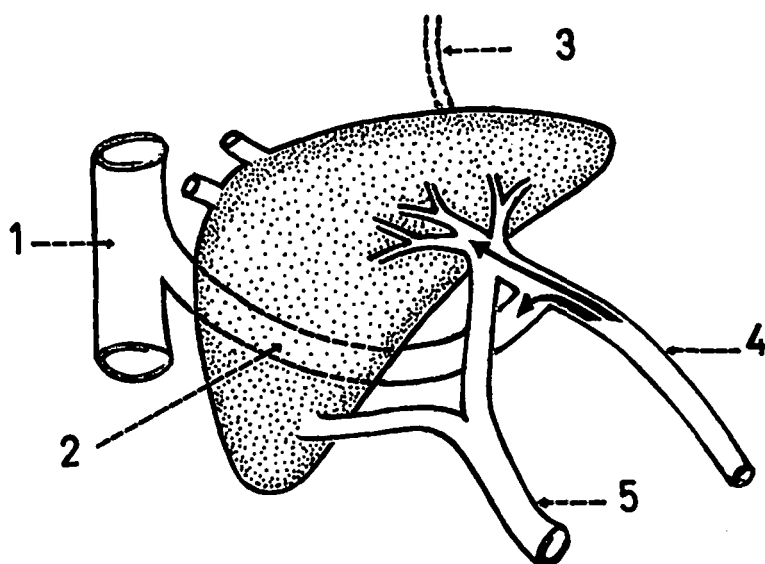


Fig.(106): DUCTUS VENOSUS

1. inferior vena cava.
2. ductus venosus (between left umbilical vein and inferior vena cava).
3. degenerated cranial part of left umbilical vein.
4. left umbilical vein.
5. portal vein (its left branch joins the left umbilical vein).

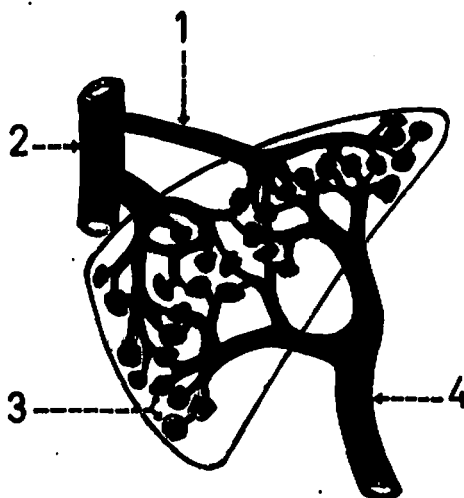


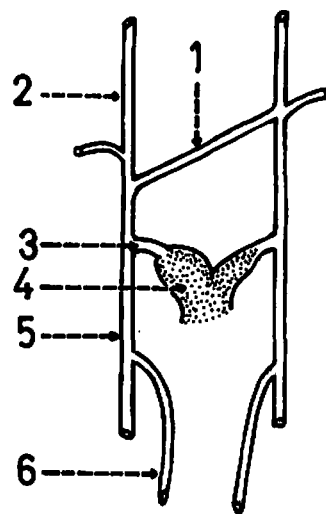
Fig.(107): HEPATIC SINUSOIDS

1. hepatic vein.
2. inferior vena cava.
3. hepatic sinusoids.
4. portal vein.

Fig.(108): ANTERIOR AND POSTERIOR CARDINAL VEINS

(a) Early stage:

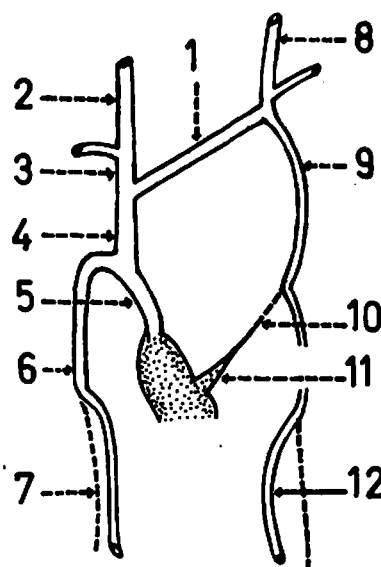
1. transverse anastomosis between the two anterior cardinal veins.
2. right anterior cardinal vein.
3. right common cardinal vein (duct of Cuvier).
4. right horn of sinus venosus.
5. posterior cardinal vein.
6. azygos line vein (joining the posterior cardinal vein).



(a)

(b) Advanced stage:

1. left brachiocephalic vein.
2. right internal jugular vein.
3. right brachiocephalic vein.
4. upper 1/2 of superior vena cava.
5. lower 1/2 of superior vena cava (from right common cardinal vein).
6. azygos vein.
7. degenerated caudal part of posterior cardinal vein.
8. left internal jugular vein.
9. left superior intercostal vein.
10. oblique vein of left atrium.
11. coronary sinus.
12. hemiazygos vein.



(b)

Fig.(109): T.S. IN THE TRUNK (ABDOMEN)
OF THE EMBRYO
(to show the arrangement of
the longitudinal veins on
both sides)

1. supracardinal vein.
2. sympathetic chain.
3. azygos line vein.
4. mesonephros.
5. coelomic cavity.
6. dorsal aorta.
7. posterior cardinal vein.
8. subcardinal vein.
9. gut.

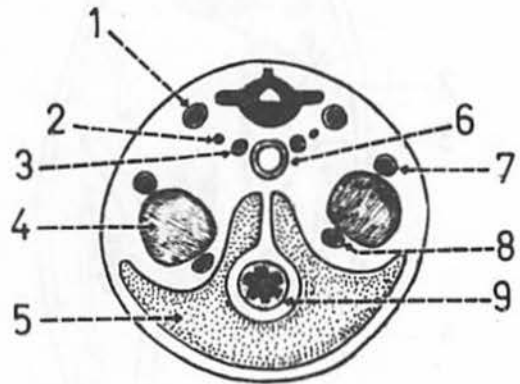
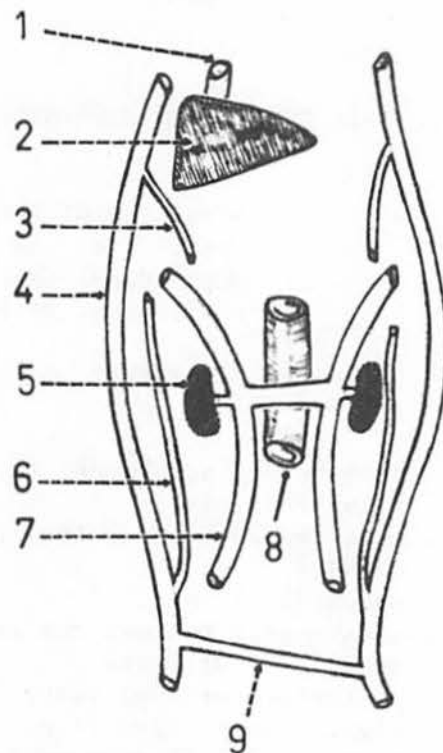


Fig.(110): LONGITUDINAL VEINS RUNNING
ON THE POSTERIOR ABDOMINAL
WALL

1. Hepato-cardiac channel (cranial part of right vitelline vein).
2. liver.
3. azygos line vein (ending in the posterior cardinal vein).
4. posterior cardinal vein.
5. metanephros (permanent kidney).
6. supracardinal vein.
7. subcardinal vein (veins of both sides show transverse anastomosis in front of the aorta).
8. aorta.
9. transverse anastomosis between the two posterior cardinal veins.



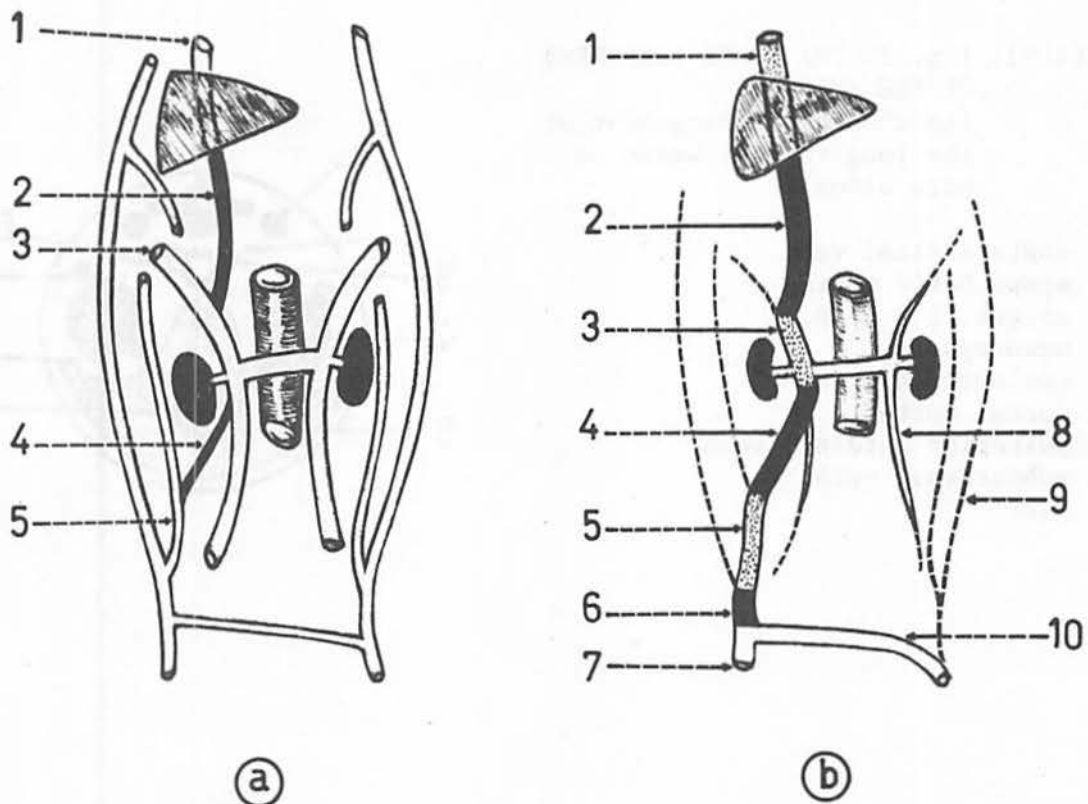


Fig.(111): DEVELOPMENT OF INFERIOR VENA CAVA (I.V.C.)

(a) Formation of two longitudinal anastomoses on the right side: one between the supracardinal and subcardinal veins, and the other between the subcardinal vein and hepato-cardiac channel.

(b) Final form of I.V.C.:(from 6 segments)

1. hepato-cardiac channel (from the cranial part of right vitelline vein).
2. anastomosis between the subcardinal vein and hepato-cardiac channel.
3. subcardinal vein.
4. anastomosis between the supracardinal and subcardinal veins.
5. supracardinal vein.
6. posterior cardinal vein.
7. right common iliac vein.
8. remnant of left subcardinal vein.
9. degenerated veins of left side.
10. left common iliac vein.

Fig.(112): RENAL COLLAR OF VEINS

1. dorsal aorta.
2. supracardinal veins and intersupracardinal anastomosis.
3. subcardinal veins and intersubcardinal anastomosis.



N.B.: The renal collar is a ring of venous anastomosis around the aorta opposite the renal veins.

Fig.(113): RENAL, GONADAL AND SUPRARENAL VEINS

1. aorta.
2. right renal vein (from the metanephric vein).
3. right gonadal vein (from the subcardinal vein).
4. left suprarenal vein (from the subcardinal vein).
5. left renal vein (from the metanephric vein and the intersubcardinal anastomosis).
6. intersubcardinal anastomosis.

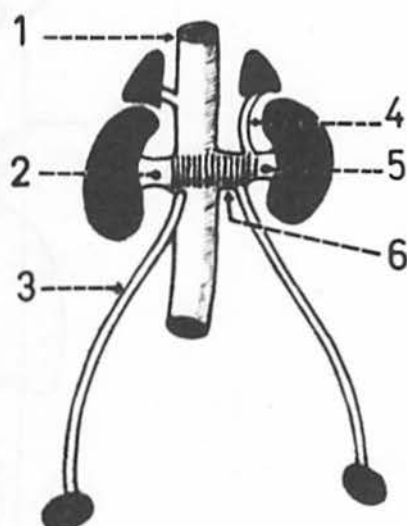
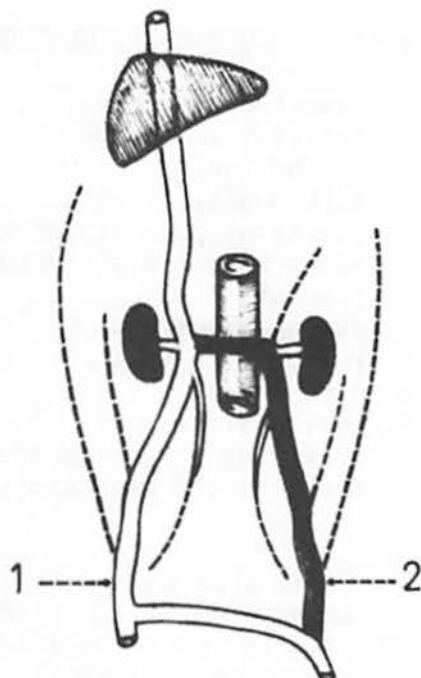


Fig.(114): DOUBLE INFERIOR VENA CAVA

1. right I.V.C.
2. abnormal left I.V.C. (below the level of the left renal vein and crosses the midline opposite the kidney to join the right I.V.C.).



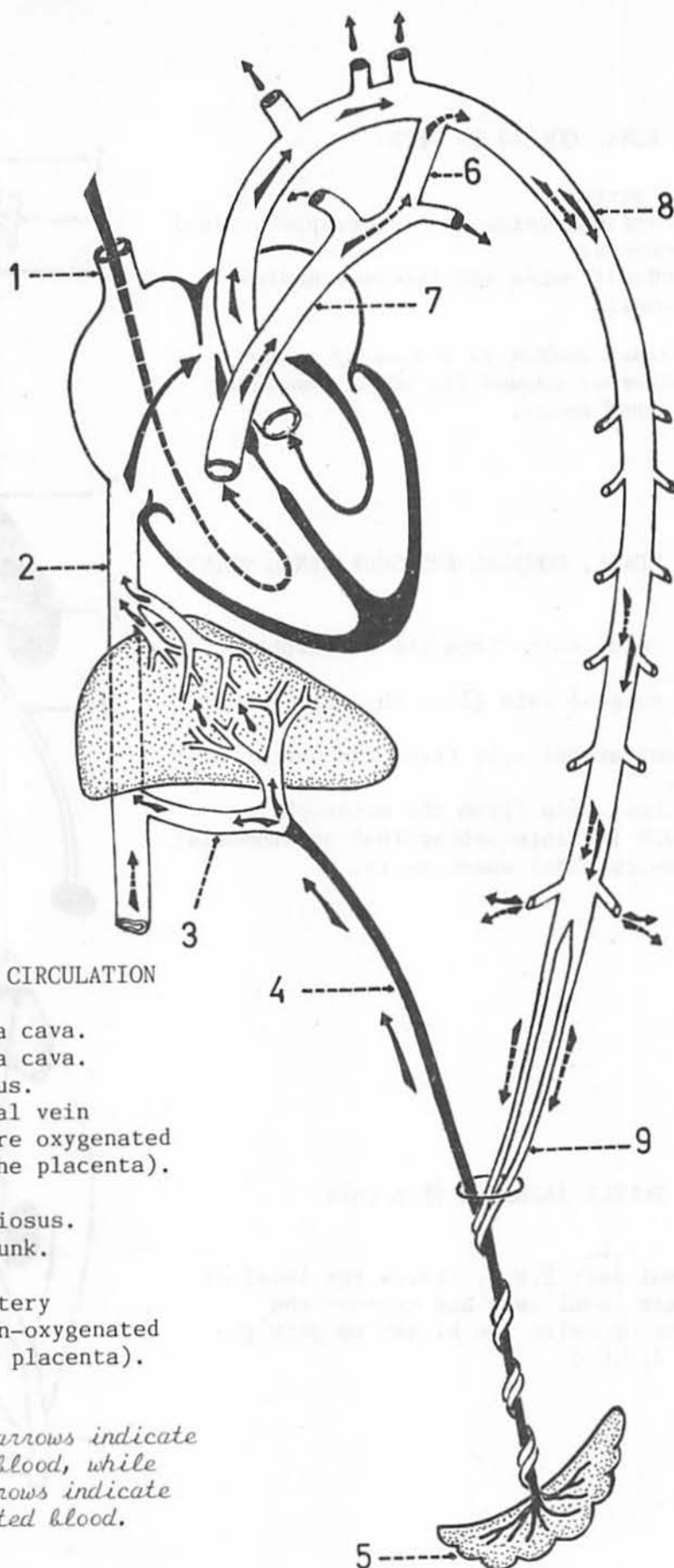


Fig.(115): FOETAL CIRCULATION

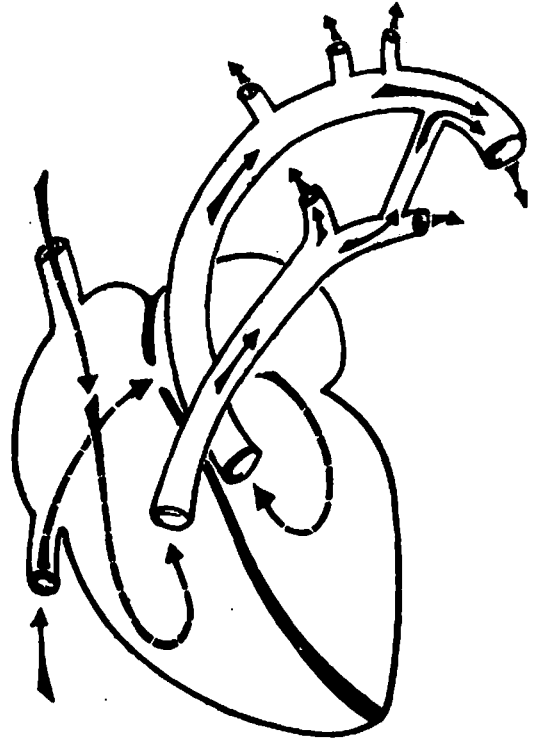
1. superior vena cava.
2. inferior vena cava.
3. ductus venosus.
4. left umbilical vein
(carrying pure oxygenated
blood from the placenta).
5. placenta.
6. ductus arteriosus.
7. pulmonary trunk.
8. aorta.
9. umbilical artery
(carrying non-oxygenated
blood to the placenta).

*N.B.: Continuous arrows indicate
oxygenated blood, while
stippled arrows indicate
non-oxygenated blood.*

Fig.(116): BLOOD CIRCULATION IN THE
HEART CHAMBERS

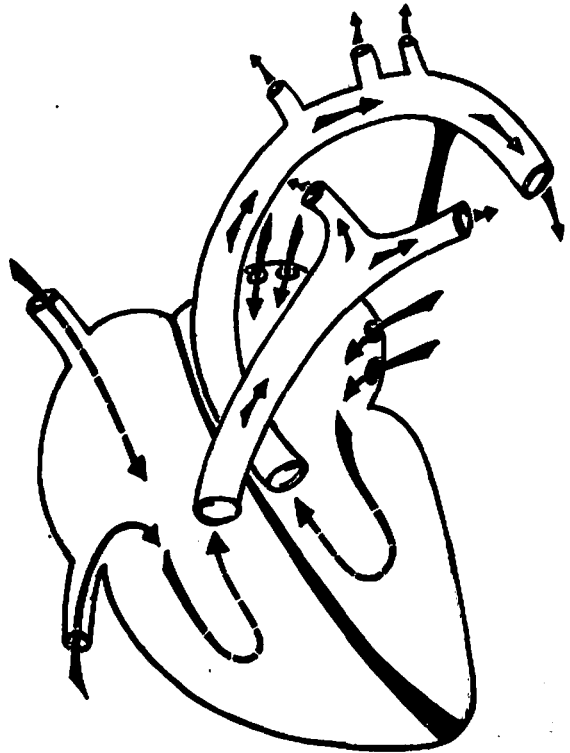
(a) In the foetus

(a)



(b) In the adult

(b)



BRANCHIAL SYSTEM

PHARYNGEAL (BRANCHIAL) ARCHES

Fig.(117): PHARYNGEAL ARCHES
(side-view of the head fold)

1. forebrain bulge.
2. stomodeum.
3. pericardial bulge.
4. the six pharyngeal arches.

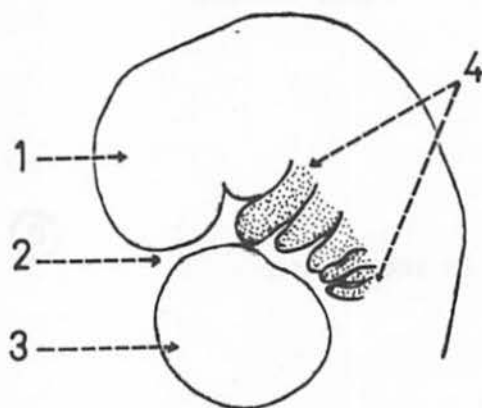


Fig.(118): PHARYNGEAL ARCHES
(coronal section of the pharynx)

1. 6th arch.
2. 1st arch.
3. lateral wall of pharynx.
4. floor of pharynx.

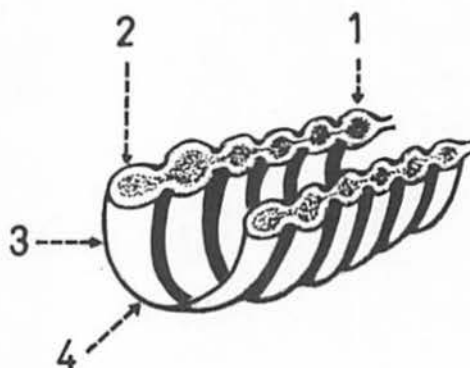
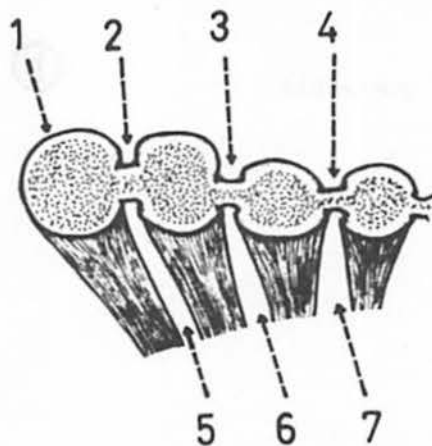


Fig.(119): PHARYNGEAL CLEFTS AND
PHARYNGEAL POUCHES

1. the 1st arch.
2. the 1st cleft.
3. the 2nd cleft.
4. the 3rd cleft.
5. the 1st pouch.
6. the 2nd pouch.
7. the 3rd pouch.



N.B.: The pharyngeal clefts are ectodermal while the pharyngeal pouches are endodermal.

Fig.(120): VENTRAL ENDS OF PHARYNGEAL ARCHES
(as seen in the floor of the pharynx)

1. the 1st and 2nd arches.
2. caudal extension of the 2nd arch over the 3rd and 4th arches.
3. the 3rd and 4th arches.
4. the 5th arch.
5. the 6th arch.
6. hypobranchial eminence in the floor of pharynx.

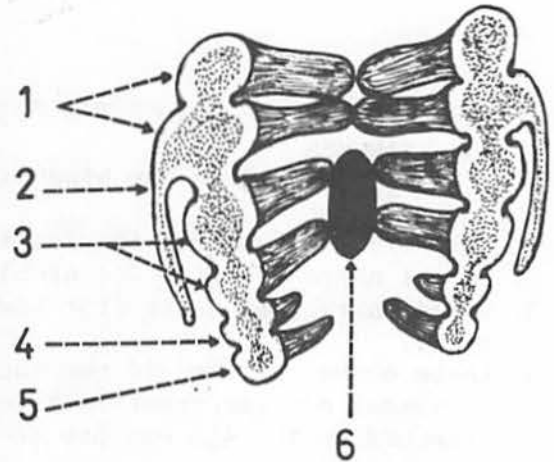


Fig.(121): BASIC STRUCTURE OF THE PHARYNGEAL ARCHES

1. the 1st pharyngeal arch.
2. the 1st aortic arch (artery).
3. trigeminal nerve (nerve of the 1st arch).
4. facial nerve (nerve of the 2nd arch).
5. glossopharyngeal nerve (nerve of the 3rd arch).
6. superior laryngeal nerve (nerve of the 4th arch).
7. recurrent laryngeal nerve (nerve of the 6th arch).

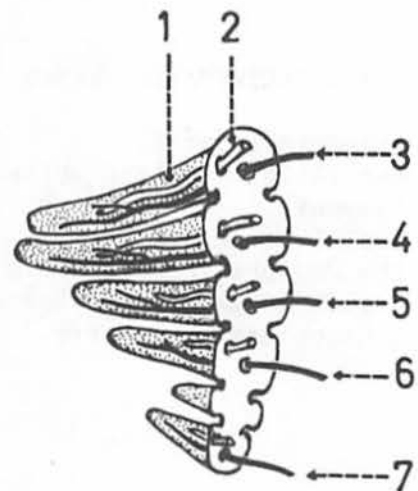


Fig.(122): CRANIAL NERVES OF THE PHARYNGEAL ARCHES
(arising from the hindbrain)

1. trigeminal nerve (for the 1st arch).
2. facial nerve (for the 2nd arch).
3. glossopharyngeal nerve (for the 3rd arch).
4. vagus nerve (giving off the superior laryngeal and recurrent laryngeal branches to the 4th and 6th arches respectively).
5. hindbrain.

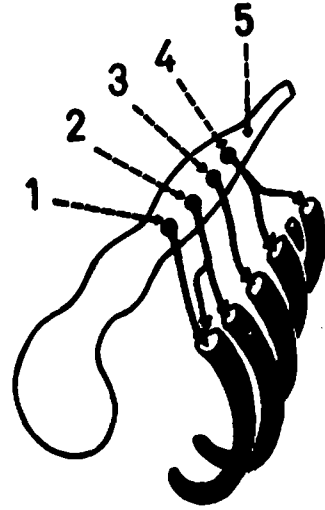


Fig.(123): PRETREMATIC NERVES

1. trigeminal nerve.
2. the 1st pretrematic nerve (chorda tympani).
3. facial nerve.
4. the 2nd pretrematic nerve (tympanic branch of glossopharyngeal nerve).
5. glossopharyngeal nerve.

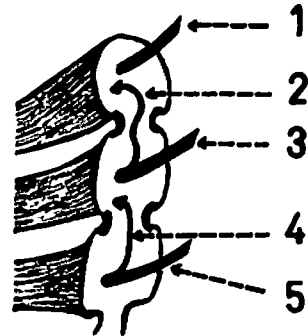


Fig.(124): SKELETAL DERIVATIVES OF PHARYNGEAL ARCHES

- (a) Derivatives of 1st arch
- (b) Derivatives of 2nd arch
- (c) Derivatives of 3rd arch
- (d) Derivatives of 4th and 6th arches

1. incus (an ossicle of the middle ear).
2. malleus (an ossicle of the middle ear).
3. anterior malleolar ligament.
4. sphenomandibular ligament.
5. Meckel's cartilage.
6. stapes (an ossicle of the middle ear).
7. styloid process.
8. stylohyoid ligament.
9. lesser horn of hyoid bone.
10. upper part of body of hyoid bone.
11. greater horn of hyoid bone.
12. lower part of body of hyoid bone.
13. thyroid cartilage.
14. cricoid cartilage.

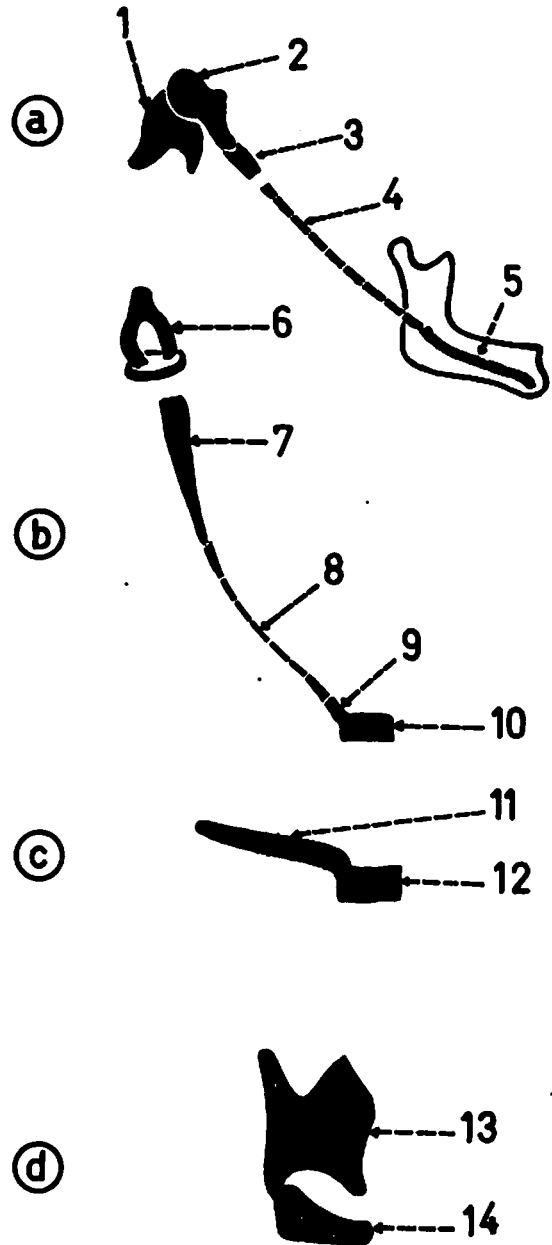


Fig.(125): ENDODERMAL DERIVATIVES OF PHARYNGEAL POUCHES

1. the 1st arch.
2. the 1st cleft.
3. cervical sinus.
4. tubo-tympanic recess (from the 1st pouch; becomes the middle ear and auditory tube).
5. palatine tonsil (from the 2nd pouch).
6. thymus and inferior parathyroid gland (from the 3rd pouch).
7. superior parathyroid gland (from the 4th pouch).
8. ultimobranchial body (from the 5th arch).

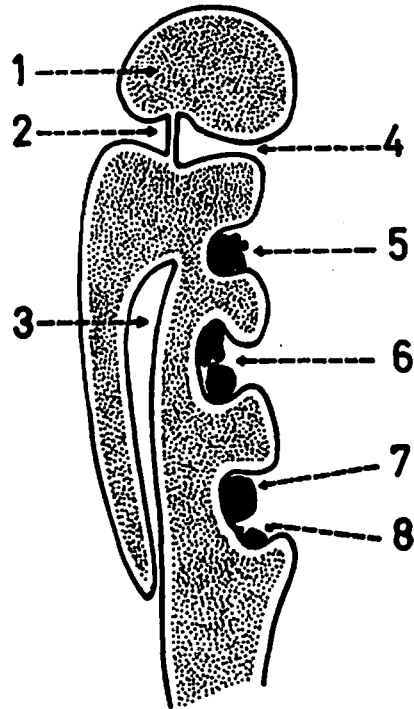


Fig.(126): ECTODERMAL DERIVATIVES OF PHARYNGEAL CLEFTS

1. cavity of the pharynx.
2. the 1st arch.
3. external auditory meatus (from the 1st cleft).
4. the 2nd arch.
5. cervical sinus (its floor is formed by the 3rd and 4th arches).
6. roof of the cervical sinus (formed by caudal extension of the 2nd arch).
7. tubercles of the ear pinna (the tragus is derived from the 1st arch, while the rest of the pinna is from the 2nd arch).

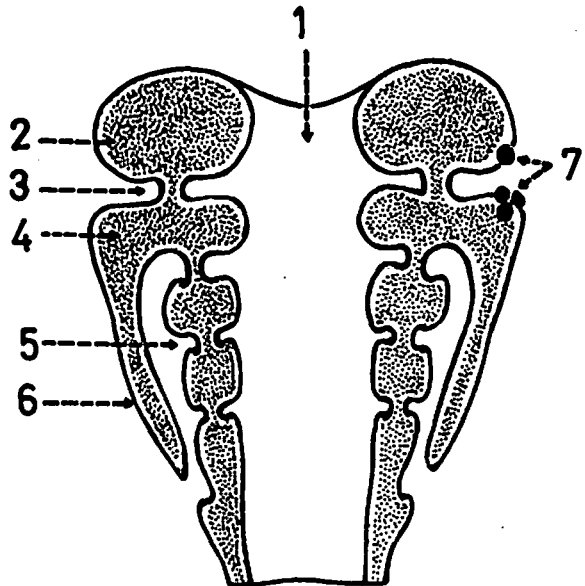
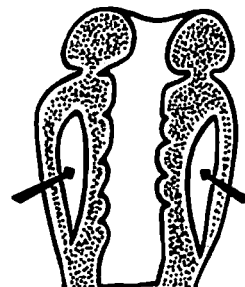


Fig.(127): ANOMALIES OF CERVICAL SINUS

(a) Branchial cyst:

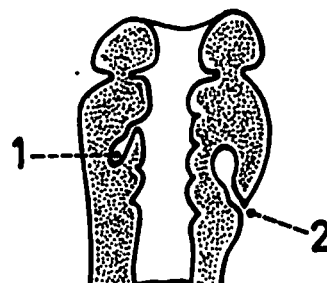
persistence of the cervical sinus as a closed cavity.



(a)

(b) Branchial fistula:

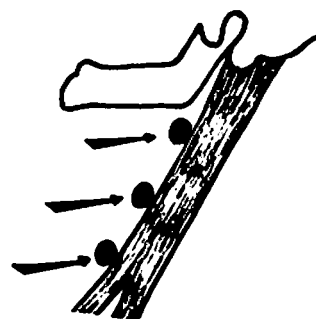
1. internal fistula opening into the cavity of the pharynx close to the tonsil.
2. external fistula opening on the side of the neck.



(b)

(c) Common sites of external branchial fistulae:

open on the side of the neck along the anterior border of the sternomastoid muscle.



(c)

FACE, NOSE AND PALATE

FACE

Fig.(128): DEVELOPMENT OF THE FACE
(side view)

1. frontonasal process.
2. maxillary process (from 1st arch).
3. stomodeum.
4. pericardial bulge.

N.B.: The face develops from the frontonasal process as well as from the maxillary and mandibular processes of the 1st arch of both sides (i.e. from 5 processes).

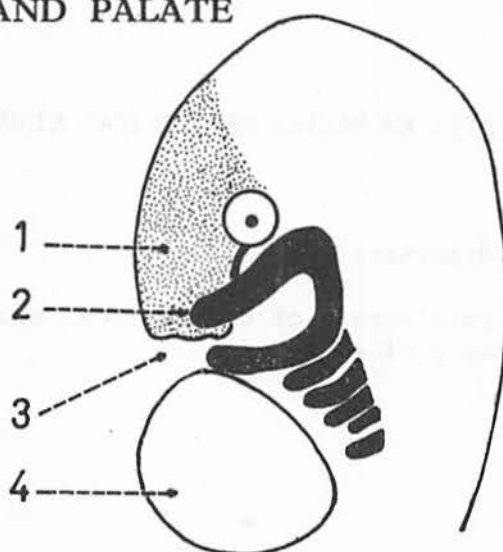


Fig.(129): NASOLACRIMAL DUCT

1. eyeball.
2. nasolacrimal cord (solid ectodermal cord which later canalizes).
3. maxillary process of 1st arch.
4. stomodeum.

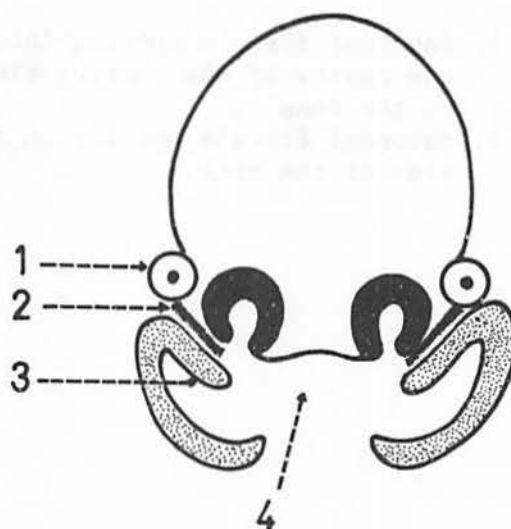


Fig.(130): ADULT FACE

1. part from frontonasal process.
2. part from the 1st arch.
3. ear pinna (derived from 2nd arch).

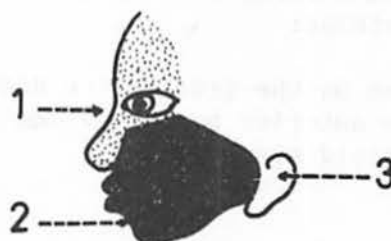


Fig.(131): DEVELOPMENT OF UPPER LIP
(generally accepted view)

1. nasal (olfactory) pit.
2. intermaxillary segment (lower end of the frontonasal process between the two maxillary processes).
3. medial nasal fold.
4. lateral nasal fold.
5. maxillary process of 1st arch (stops at the medial nasal fold).
6. stomodeum.

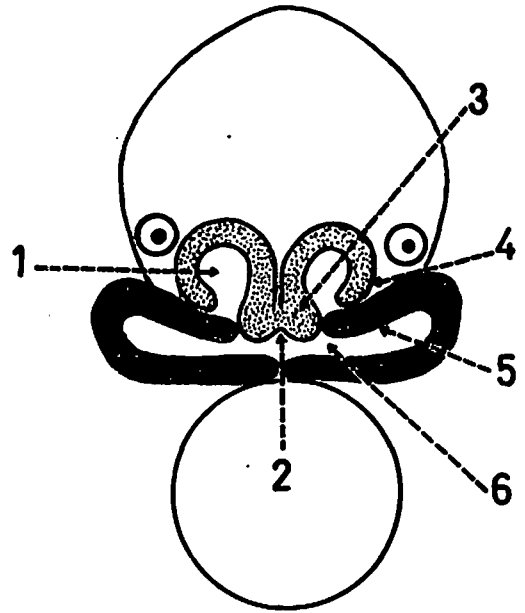


Fig.(132): DEVELOPMENT OF UPPER LIP
(another view: the two maxillary processes meet each other in the midline in front of the lower end of the frontonasal process)

1. frontonasal process.
2. meeting of the two maxillary processes in the midline.
3. nasal (olfactory) pit.
4. stomodeum.

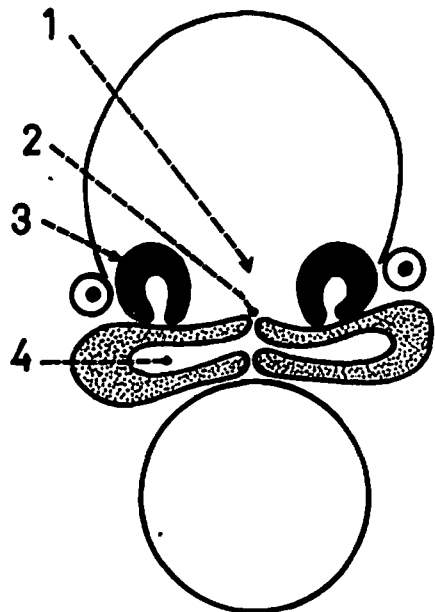
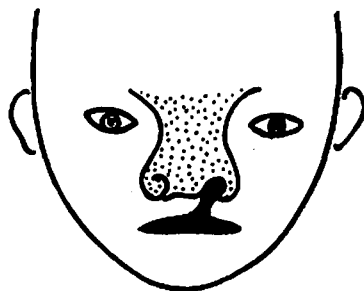


Fig.(133): ANOMALIES OF UPPER LIP AND FACE

(a) Unilateral hare-lip:

failure of one maxillary process to unite with the medial nasal fold.

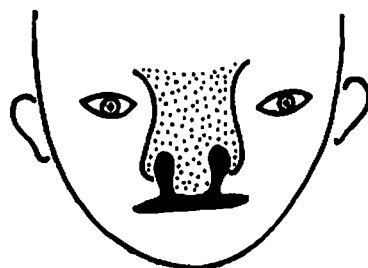
(a)



(b) Bilateral hare-lip:

failure of the two maxillary processes to unite with the medial nasal folds of both sides.

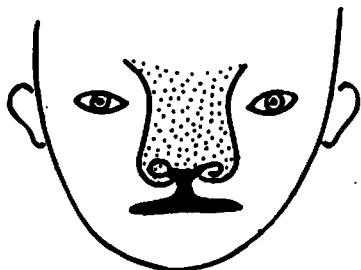
(b)



(c) Median hare-lip:

incomplete development of the two medial nasal folds (i.e. a defect in the frontonasal process).

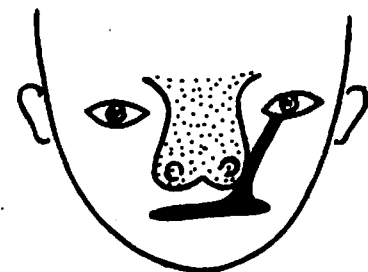
(c)



(d) Oblique facial cleft:

failure of fusion between the maxillary process and side of the frontonasal process.

(d)



N O S E

Fig.(134): STAGE OF OLFACTORY PLACODE
(frontal view)

1. forebrain bulge.
2. frontonasal process.
3. olfactory placode (area of ectodermal thickening).
4. maxillary process.
5. mandibular process.
6. pericardial bulge.
7. stomodeum.
8. eyeball.

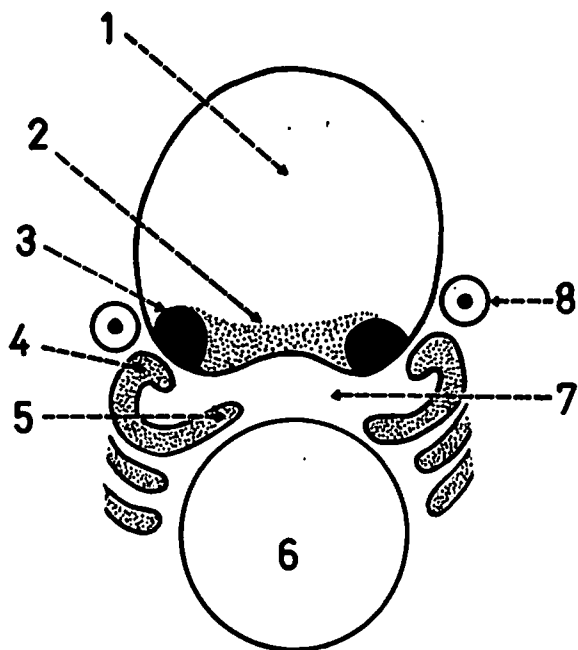


Fig.(135): STAGE OF OLFACTORY PLACODE
(side view)

1. maxillary process.
2. eyeball.
3. forebrain bulge.
4. frontonasal process.
5. olfactory placode.
6. mandibular process.
7. pericardial bulge.

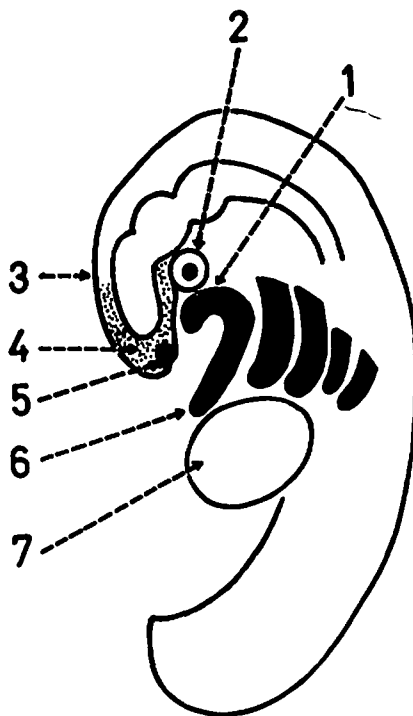


Fig.(136): STAGE OF OLFACTORY OR NASAL PIT

1. nasal pit (depressed olfactory placode).
2. lateral nasal fold.
3. stomodeum.
4. pericardial bulge.
5. medial nasal fold.
6. frontonasal process.
7. maxillary process.
8. mandibular process.

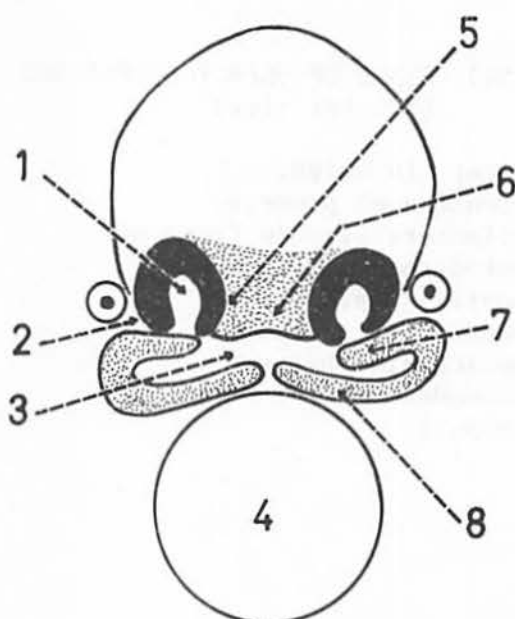
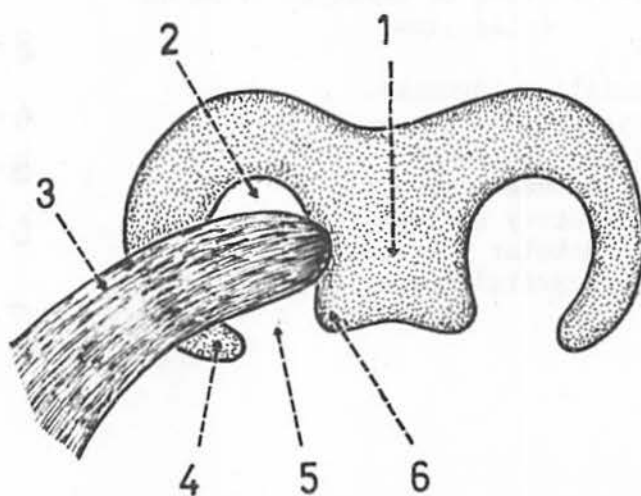


Fig.(137): THE NASAL PIT SEEN FROM BELOW

1. lower end of frontonasal process (intermaxillary segment).
2. anterior naris (anterior opening of the primitive nasal cavity).
3. maxillary process.
4. lateral nasal fold.
5. posterior naris of the primitive nasal cavity.
6. medial nasal fold.



P A L A T E

Fig.(138): DERIVATIVES OF INTERMAXILLARY SEGMENT
(the segment between the tips of the two maxillary processes)

1. median part of upper lip or philtrum (from intermaxillary segment).
2. median part of upper jaw which carries the four incisors (from intermaxillary segment).
3. primitive palate (from intermaxillary segment).
4. upper lip and cheek (from maxillary process).
5. upper jaw (from maxillary process).
6. palatal process (from maxillary process).
7. lower edge of definitive nasal septum.

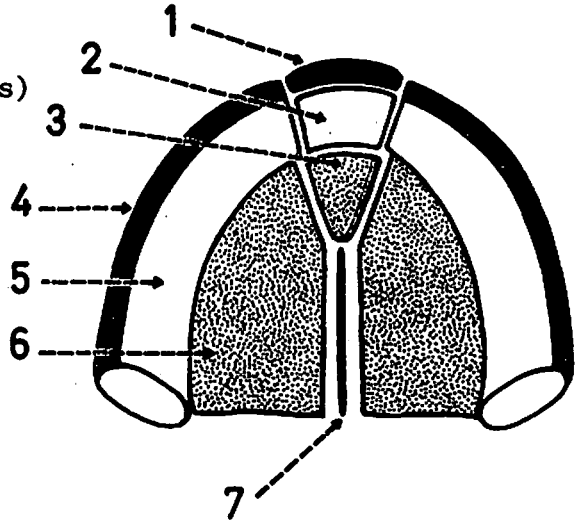


Fig.(139): EARLY STAGE OF PALATE

1. primitive palate (from intermaxillary segment).
2. maxillary process.
3. palatal process.
4. lower edge of the definitive nasal septum.

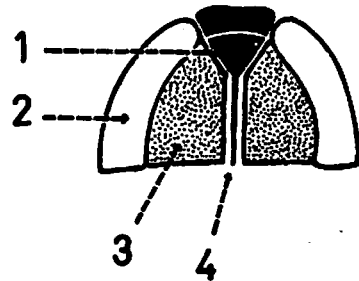
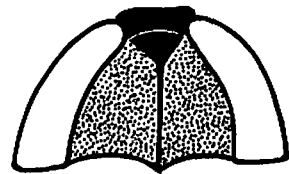


Fig.(140): ADVANCED STAGE OF PALATE

The three components of the palate are fused together.



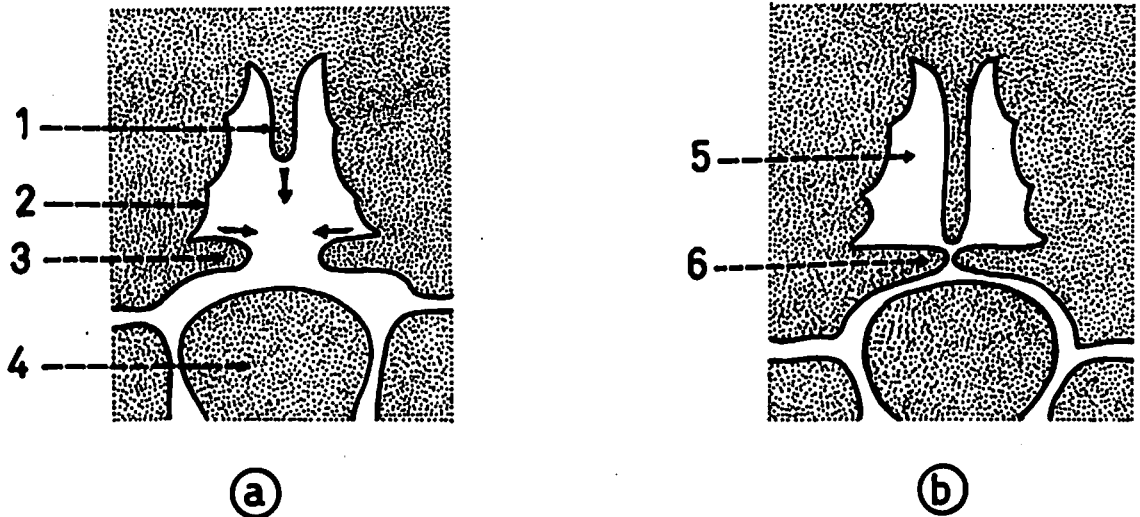


Fig.(141): CORONAL SECTION IN THE HEAD TO SHOW NASAL SEPTUM AND PALATE

- (a) Early stage:
the nasal and oral cavities are continuous together.
- (b) Advanced stage:
the nasal and oral cavities are completely separated
by meeting of the nasal septum with the palate.

1. definitive nasal septum growing downwards.
2. lateral wall of nasal cavity with conchae.
3. palatal process growing inwards.
4. tongue (in the oral cavity just below the palatal processes).
5. right side of nasal cavity.
6. the two palatal processes meeting each other in the midline.

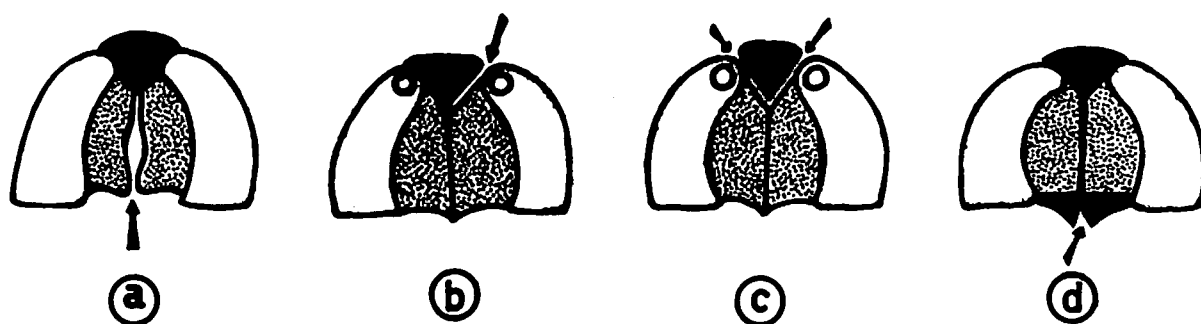


Fig.(142): ANOMALIES OF THE PALATE

- (a) Isolated cleft palate (in the midline).
- (b) Unilateral cleft palate (involving the upper jaw just medial to the canine tooth).
- (c) Bilateral cleft palate (involving the upper jaw medial to the canines on both sides).
- (d) Bifid uvula and soft palate (the defect is in the most posterior end of the palate).

ORAL CAVITY

TONGUE

Fig.(143): EARLY STAGE OF THE TONGUE

1. two lingual swellings (1st arch).
2. tuberculum impar (1st arch).
3. foramen caecum.
4. anterior part of hypobranchial eminence (3rd arch).
5. posterior part of hypobranchial eminence (4th arch).
6. laryngo-tracheal groove.

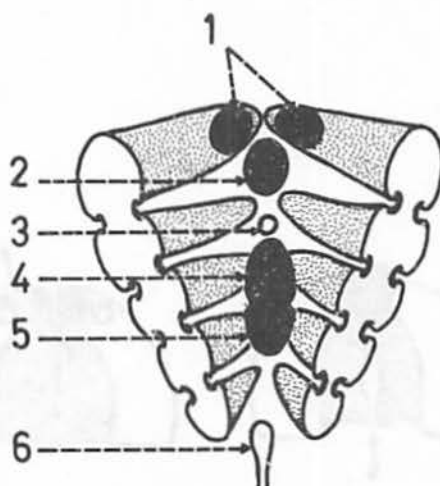
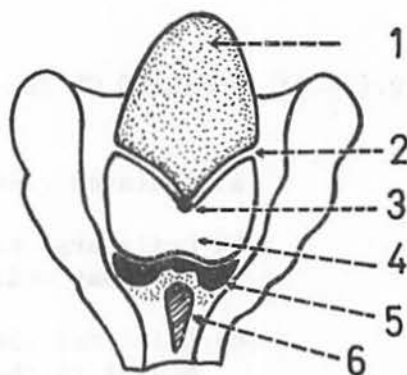


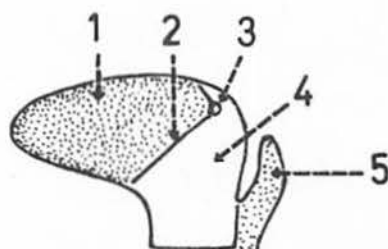
Fig.(144): ADVANCED STAGE OF THE TONGUE

- (a) Dorsum of tongue
(b) side view of tongue

1. anterior 2/3 of tongue (from two lingual swellings and tuberculum impar).
2. sulcus terminalis (between anterior 2/3 and posterior 1/3).
3. foramen caecum (origin of thyroglossal duct).
4. posterior 1/3 (from hypobranchial eminence).
5. epiglottis (from posterior part of hypobranchial eminence).
6. laryngo-tracheal groove.



(a)



(b)

N.B.: The endodermal components of the tongue forms its mucous envelope while its muscles are derived from occipital myotomes.

PAROTID GLAND

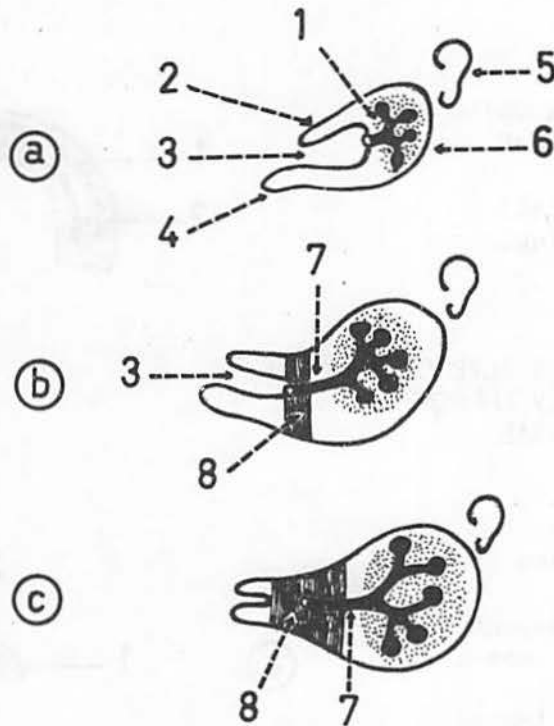


Fig.(145): DEVELOPMENT OF PAROTID GLAND

- (a) Early stage : bud of ectodermal cells at the angle of primitive oral fissure.
- (b) Formation of parotid duct: opens at 1st at the angle of primitive oral fissure.
- (c) Advanced stage: shift of the opening of parotid duct away from the angle of definitive oral fissure.

1. bud of ectodermal cells.
2. maxillary process of 1st arch.
3. primitive oral fissure.
4. mandibular process of 1st arch.
5. ear pinna.
6. mesoderm in the side of face.
7. parotid duct.
8. buccinator (pierced by the parotid duct).

ALVEOLAR ARCH AND TEETH

Fig.(146): ALVEOLAR ARCH SHOWING TWO ECTODERMAL LAMINAE

1. outer ectodermal lamina.
2. inner ectodermal lamina.

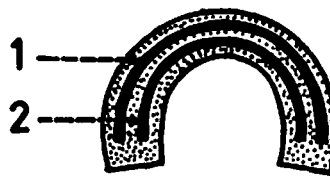
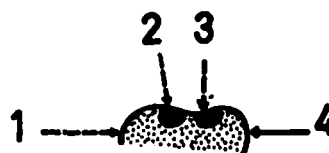


Fig.(147): CROSS SECTION IN ALVEOLAR ARCH TO SHOW DEVELOPMENT OF THE TWO LAMINAE

(a) Two ectodermal laminae

1. inner (lingual) aspect.
2. inner ectodermal lamina (or dental lamina).
3. outer ectodermal lamina.
4. outer (labial) aspect.

(a)



(b) Alveolo-labial sulcus

5. alveolo-labial sulcus (future vestibule of mouth).
6. mesoderm of 1st arch.

(b)



(c) Deciduous tooth bud

7. deciduous tooth bud (arising from the dental lamina).
8. lip or cheek.

(c)



(d) Permanent tooth bud

9. permanent tooth bud (arising from the internal lamina).
10. dental organ of deciduous tooth showing dental papilla (marked by arrow).

(d)

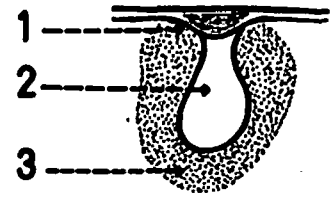


Fig.(148): DEVELOPMENT OF TEETH

(a) Formation of tooth bud

1. dental lamina (ectodermal).
2. tooth bud (becomes invaginated).
3. mesoderm.

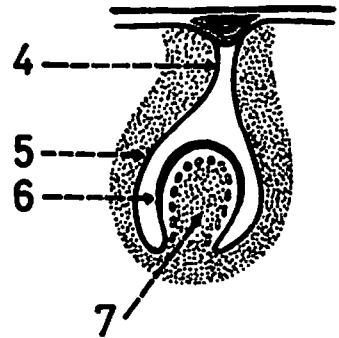
(a)



(b) Formation of dental organ

4. narrow stalk.
5. outer dental layer.
6. inner dental layer.
7. dental papilla (formed of mesoderm).

(b)



(c) Appearance of ameloblasts and odontoblasts

8. ameloblasts (from inner dental layer, i.e. ectodermal).
9. odontoblasts (from the surface of dental papilla, i.e. mesodermal).
10. blood vessel in dental papilla.

(c)

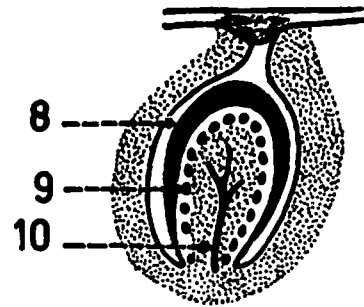
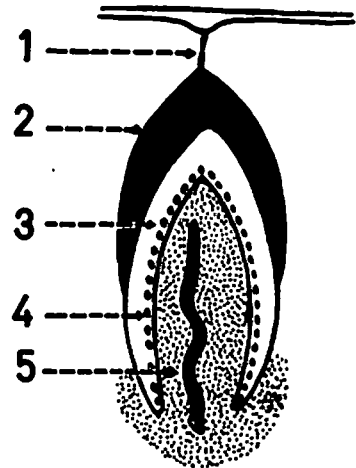


Fig.(149): ADVANCED STAGE OF TOOTH DEVELOPMENT

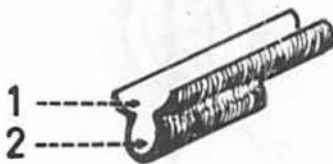
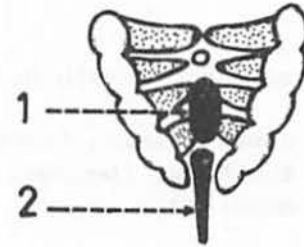
1. remnant of the stalk.
2. enamel (from ameloblasts, i.e. ectodermal).
3. dentine (from odontoblasts, i.e. mesodermal).
4. odontoblasts.
5. dental pulp showing a blood vessel.



RESPIRATORY SYSTEM

Fig.(150): LARYNGO-TRACHEAL GROOVE

1. hypobranchial eminence (in the floor of pharynx).
2. laryngo-tracheal groove (from the floor of foregut just behind the hypobranchial eminence).



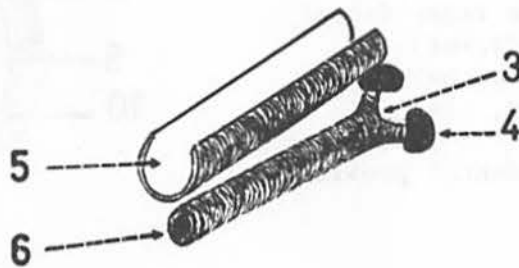
(a)



(b)



(c)



(d)

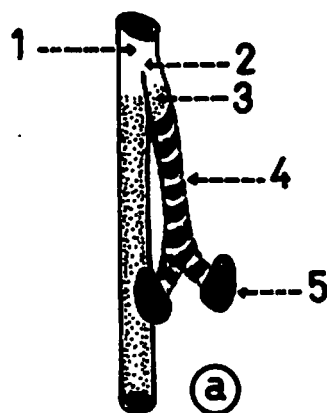
Fig.(151): TRANSFORMATION OF LARYNGO-TRACHEAL GROOVE INTO CANAL
(the trachea becomes separated from the oesophagus)

1. cranial part of foregut (oesophagus).
2. laryngo-tracheal groove (larynx and trachea).
3. the two main bronchi.
4. lung bud.
5. oesophagus.
6. trachea.

Fig.(152): DEVELOPMENT OF TRACHEA AND LUNG BUDS

(a) Early stage:

1. pharynx.
2. laryngeal aditus.
3. larynx.
4. trachea.
5. lung bud.



(b) Advanced stage:

1. lung bud invaginating the primitive pleural cavity.
2. primitive pleural cavity.

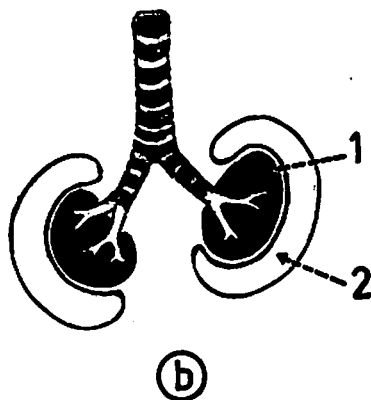
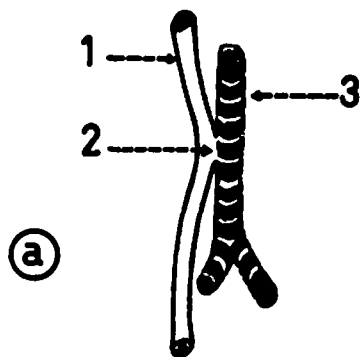


Fig.(153): TRACHEO-OESOPHAGEAL FISTULA

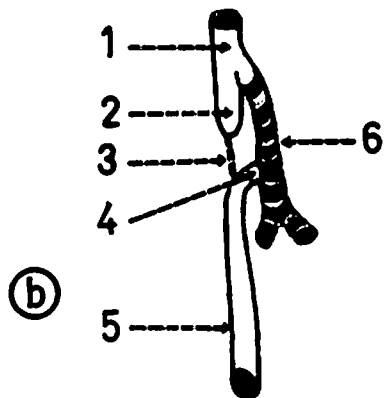
(a) Fistula between oesophagus and trachea

1. oesophagus.
2. the fistula.
3. trachea.



(b) Fistula associated with atresia of the oesophagus

1. pharynx.
2. upper blind part of oesophagus.
3. obliterated (or absent) segment of oesophagus.
4. the fistula.
5. lower normal part of oesophagus.
6. trachea.



DIGESTIVE SYSTEM

OESOPHAGUS

Fig.(154): EARLY STAGE OF OESOPHAGUS

1. oesophagus (its lumen is at first obliterated by proliferation of its lining cells then becomes canalized later on).
2. septum transversum.
3. stomach.

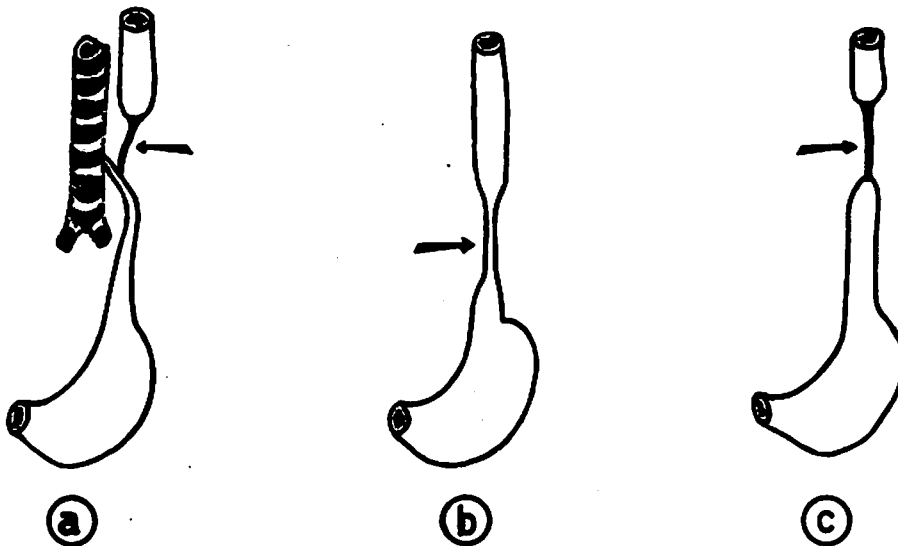
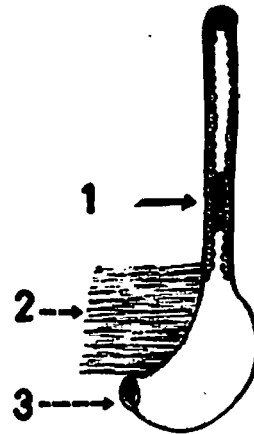


Fig.(155): ANOMALIES OF OESOPHAGUS

- (a) Oesophago-tracheal fistula associated with atresia of oesophagus.
- (b) Stenosis (narrowing) of oesophagus.
- (c) Atresia (failure of formation) of oesophagus.

MESENTERIES OF THE GUT

Fig.(156): MESENTERIES OF THE GUT

1. gut.
2. ventral mesentery (does not extend below the caudal end of foregut, i.e. has a free caudal border).
3. dorsal mesentery (extends down to the caudal end of hindgut).

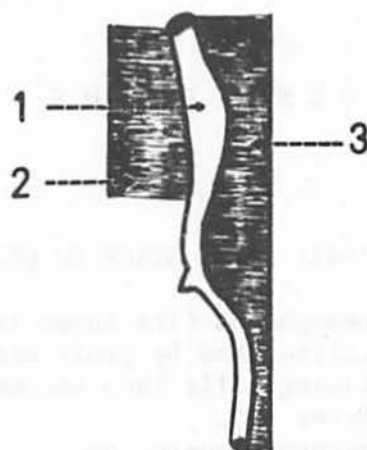


Fig.(157): MESENTERIES OF THE STOMACH

1. ventral mesogastrium.
2. liver.
3. peritoneal cavity below the free border of ventral mesogastrium.
4. dorsal mesogastrium.
5. spleen.

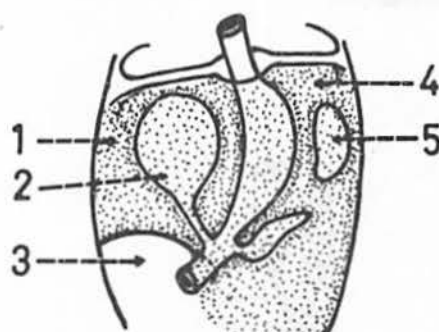
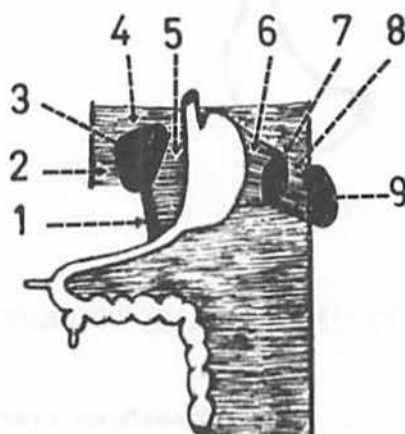


Fig.(158): STRUCTURES DEVELOPING IN THE VENTRAL AND DORSAL MESOGASTRIUM

1. bile duct (running in the free border of lesser omentum).
2. falciform ligament of liver.
3. liver.
4. coronary ligament of liver.
5. lesser omentum.
6. gastro-splenic ligament.
7. spleen.
8. lienorenal ligament.
9. left kidney.



STOMACH AND ITS MESENTERIES

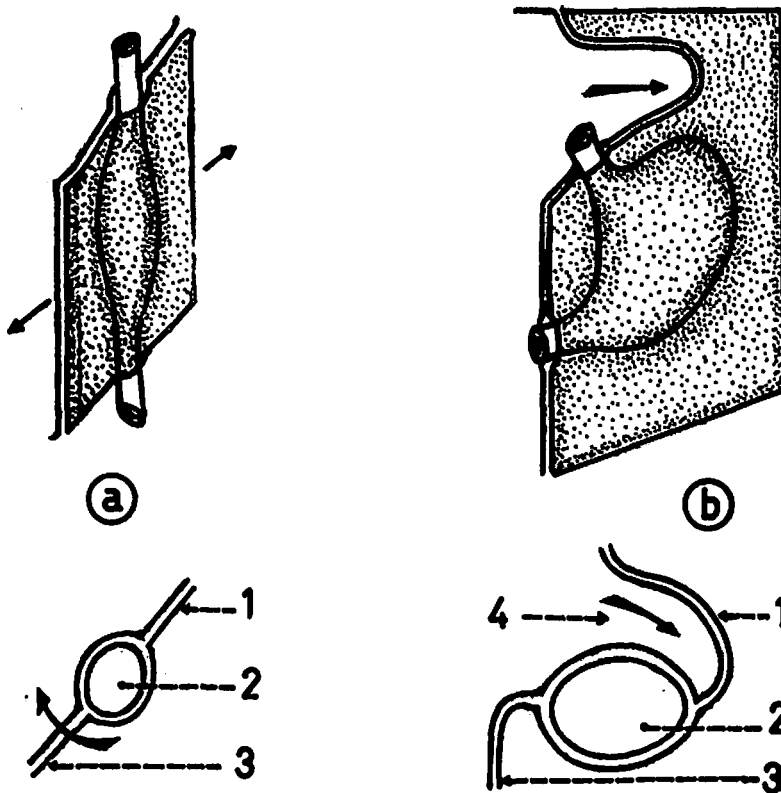


Fig.(159): DEVELOPMENT OF THE STOMACH

(a) Early stage :before rotation (the stomach is fusiform).

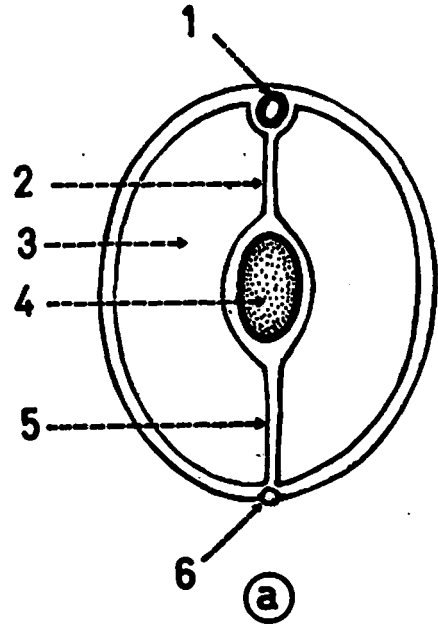
(b) Advanced stage: after rotation to the right (the stomach shows the two curvatures).

1. dorsal mesogastrium.
2. stomach.
3. ventral mesogastrium.
4. lesser sac (omental bursa).

Fig.(160): VENTRAL AND DORSAL MESOGASTRIUM
(as seen in horizontal section
of the trunk)

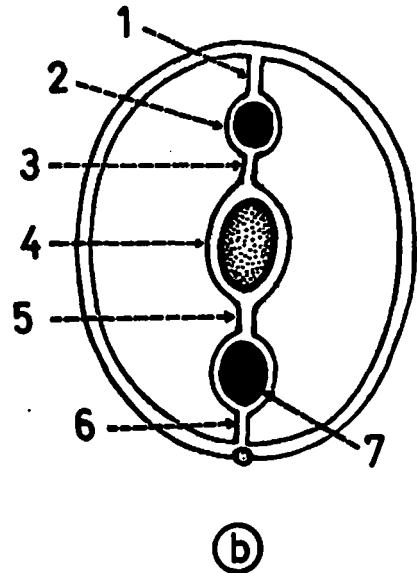
(a) Early stage (antero-posterior
partition)

1. dorsal aorta.
2. dorsal mesogastrium.
3. right half of peritoneal cavity.
4. stomach.
5. ventral mesogastrium.
6. umbilicus.



(b) Development of liver and spleen
in the two mesenteries

1. lieno-renal ligament.
2. spleen.
3. gastro-splenic ligament.
4. stomach.
5. lesser omentum.
6. falciform ligament.
7. liver.



(c) Rotation of the stomach to the right and formation of lesser sac (omental bursa)

1. liver.
2. lesser sac (omental bursa).
3. left kidney.
4. spleen.
5. stomach.
6. greater sac of peritoneum.
7. falciform ligament.

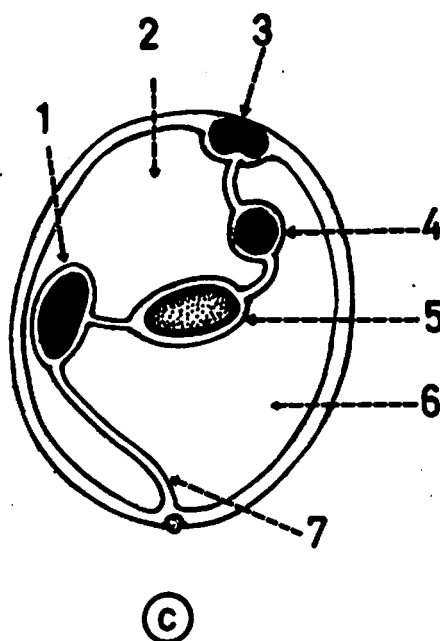
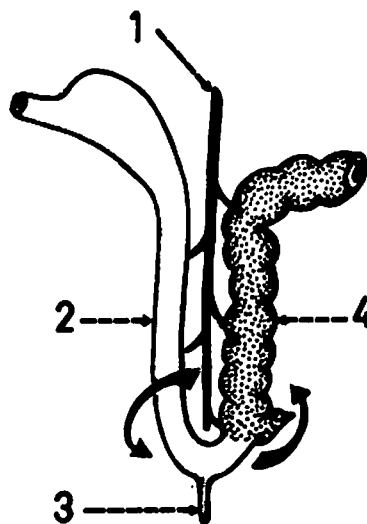


Fig.(161): LOOP OF MIDGUT
(to show anticlockwise rotation)

1. superior mesenteric artery.
2. proximal (cranial) limb of midgut.
3. vitello-intestinal duct.
4. distal (caudal) limb of midgut.

N.B.: The proximal limb consists of the caudal 1/2 of duodenum, whole jejunum and most of ileum, while the distal limb consists of the terminal part of ileum, caecum, ascending colon and right 2/3 of transverse colon.



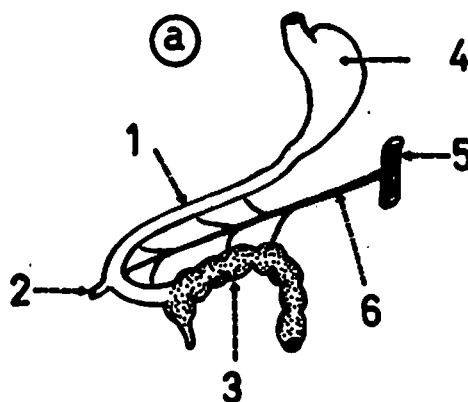
M I D G U T

Fig.(162): REDUCTION OF THE MIDGUT
LOOP HERNIATED INTO THE
UMBILICUS

(a) Before rotation:

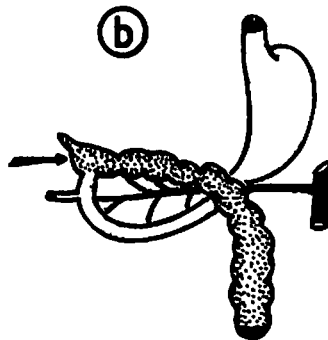
(cranial limb and caudal limb)

1. cranial limb.
2. vitello-intestinal duct.
3. caudal limb.
4. stomach.
5. aorta.
6. superior mesenteric artery.

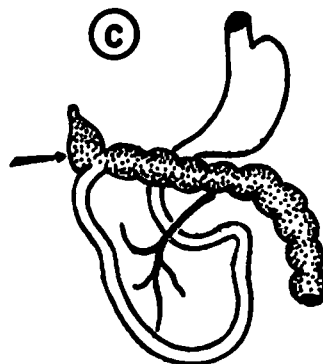


(b) Anticlockwise rotation:

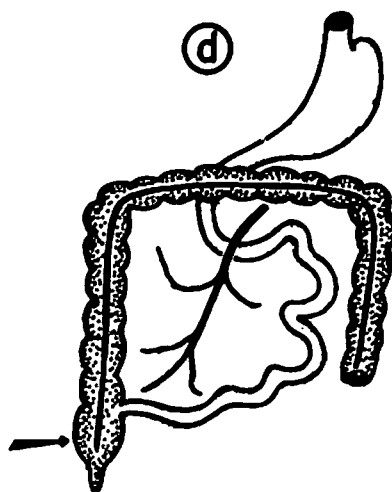
the caecum is high up and
the transverse colon comes
in front of the duodenum.



- (c) The superior mesenteric artery passes in front of the duodenum.



- (d) The caecum descends to the right iliac fossa and the ascending colon elongates.



DUODENUM

Fig.(163): DEVELOPMENT OF THE DUODENUM

1. cranial 1/2 of duodenum (from foregut).
2. caudal 1/2 of duodenum (from midgut).

N.B.: The bile and pancreatic ducts open into the terminal part of the foregut.

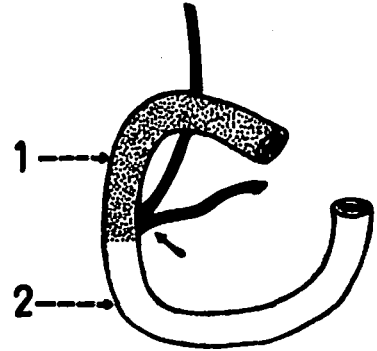


Fig.(164): PERITONEAL FOLDS AND RECESSES OF DUODENUM

1. superior duodenal fold and recess behind.
2. retroduodenal recess (behind the 3rd and 4th parts of duodenum).
3. inferior duodenal fold and recess behind.
4. paraduodenal fold and recess behind.

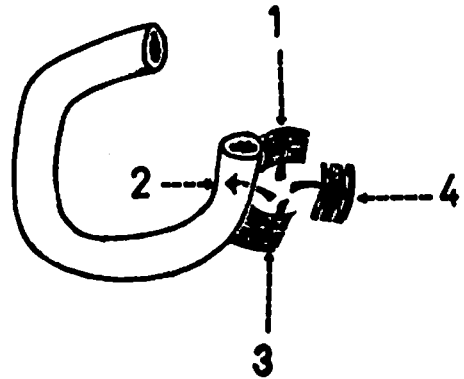


Fig.(165): DUODENAL STENOSIS

(marked by arrow)



FIXATION OF THE GUT

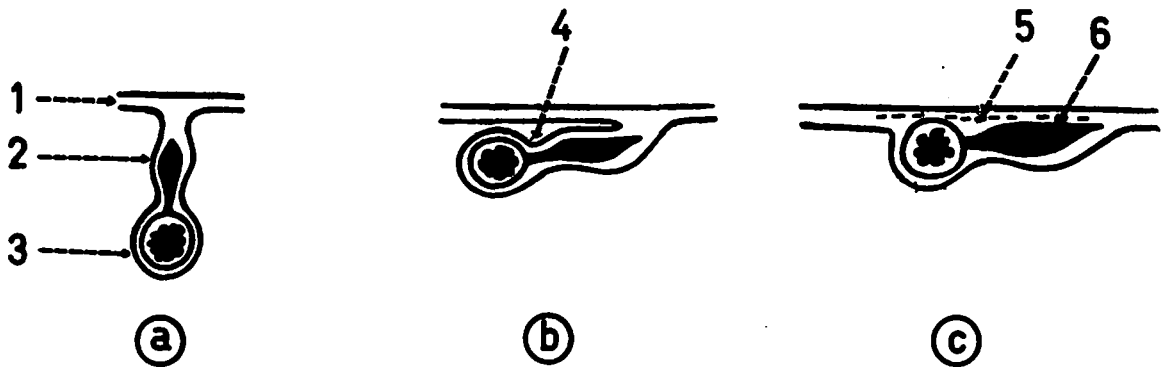


Fig.(166): FIXATION OF DUODENUM TO POSTERIOR ABDOMINAL WALL

- (a) Duodenum suspended by dorsal mesentery
- (b) Rotation of the duodenum to the right
- (c) Degeneration of the peritoneum behind the duodenum and pancreas, thus they become retroperitoneal

- 1. posterior abdominal wall covered by parietal peritoneum.
- 2. mesentery of duodenum (mesoduodenum enclosing the pancreas).
- 3. duodenum.
- 4. the two layers of peritoneum coming in contact with each other.
- 5. degeneration of intervening peritoneum.
- 6. pancreas (becomes retroperitoneal).

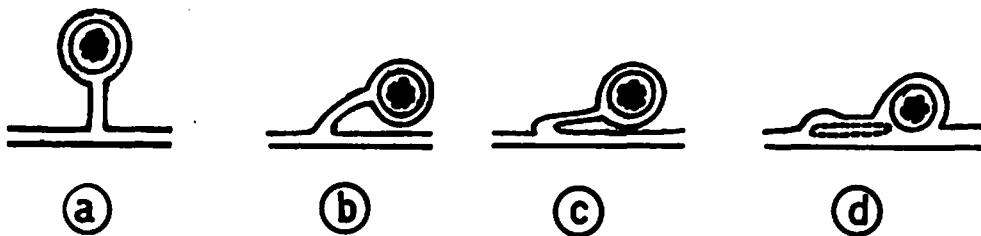


Fig.(167): FIXATION OF ASCENDING AND DESCENDING COLON TO BECOME RETROPERITONEAL

ANOMALIES OF MIDGUT

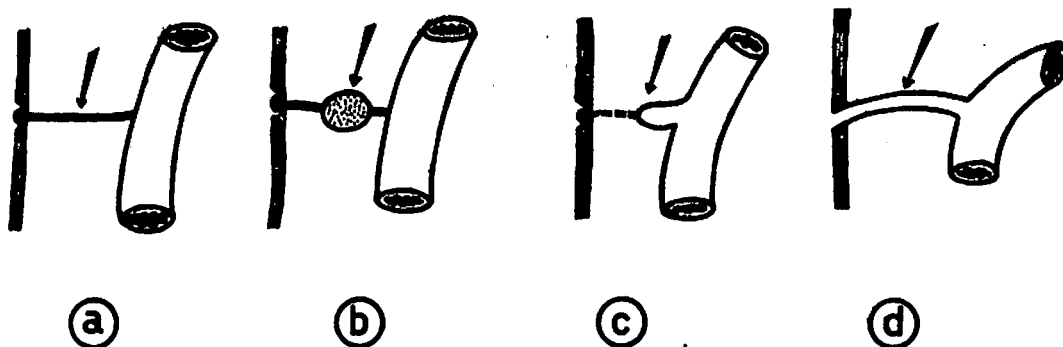
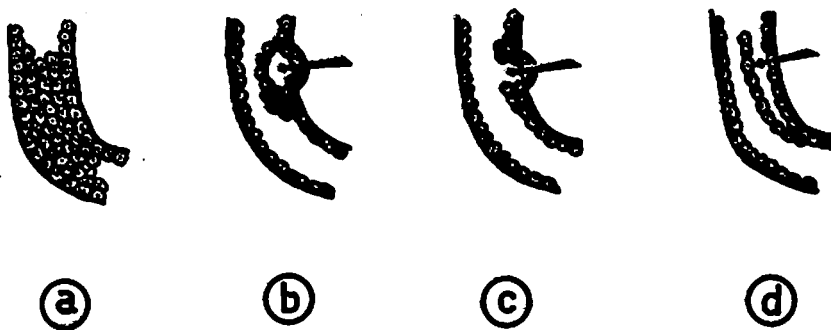


Fig.(168): ANOMALIES OF VITELLO-INTESTINAL DUCT

- (a) Persistence of fibrous cord between terminal part of ileum and umbilicus (vitelline ligament).
- (b) Presence of vitelline cyst along the vitelline ligament.
- (c) Meckel's diverticulum (present 2 feet from ileo-caecal junction).
- (d) Foecal fistula (between terminal part of ileum and umbilicus).

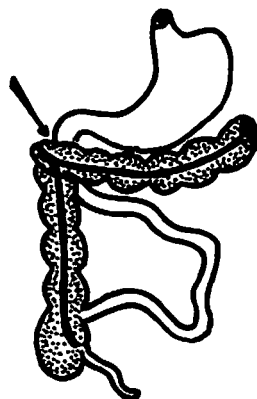
Fig.(169): DUPLICATION OF INTESTINAL LOOPS
(common in the ileum)

- (a) Intestinal segment with the lumen completely closed (a transient stage followed by recanalization).
- (b) Formation of a cyst in the wall (due to incomplete recanalization).
- (c) Formation of a diverticulum (due to irregular recanalization).
- (d) Persistence of a septum projecting inside the lumen (due to incomplete recanalization).

Fig.(170): ABNORMAL ROTATION OF MIDGUT LOOP

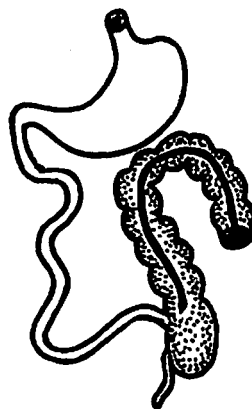
- (a) Normal anticlockwise rotation for 270° :

This brings the transverse colon in front of the duodenum.



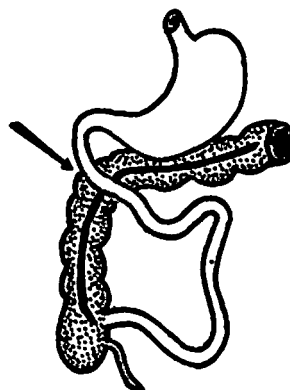
(a)

- (b) Anticlockwise rotation for only 90° :
This draws the caecum and ascending colon to the left side (situs inversus).



(b)

- (c) Reversed rotation for 90° :
This brings the transverse colon behind the duodenum.



(c)

Fig.(171): EXOMPHALOS
(congenital umbilical hernia)

1. proximal part of umbilical cord.
2. midgut loop (herniating).
3. umbilical cord.

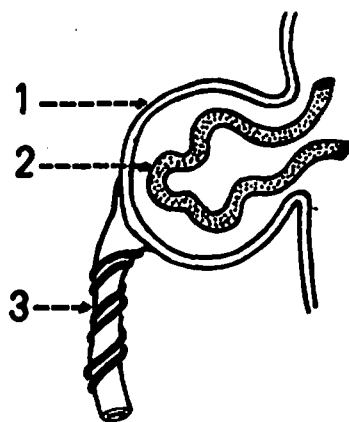


Fig.(172): SUBHEPATIC CAECUM AND APPENDIX

(due to failure of descent
of the caecum to the right
iliac fossa)

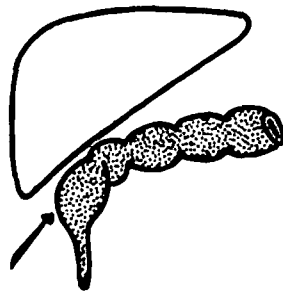
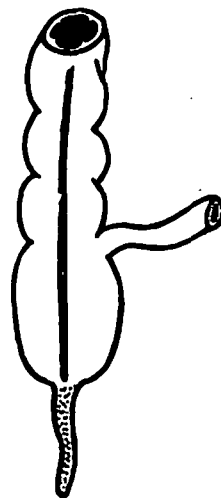


Fig.(173): FOETAL POSITION OF THE
APPENDIX

(attached to the apex of
the caecum)



H I N D G U T

RECTUM AND ANAL CANAL

Fig.(174): ENDODERMAL CLOACA

1. allantois.
2. cloacal membrane.
3. ectodermal cloaca (lined with ectoderm).
4. hindgut.
5. arrow to show the direction of growth of urorectal septum.
6. endodermal cloaca (the part of hindgut caudal to the attachment of allantois; lined with endoderm).

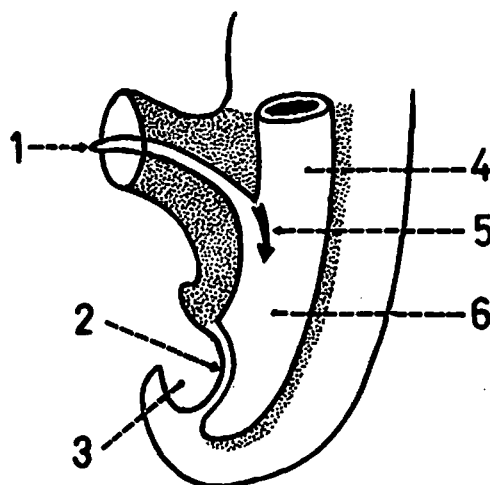


Fig.(175): FORMATION OF URORECTAL SEPTUM

1. primitive urogenital septum.
2. ectodermal cloaca.
3. rectum and upper 1/2 of anal canal.
4. urorectal septum (mesoderm).

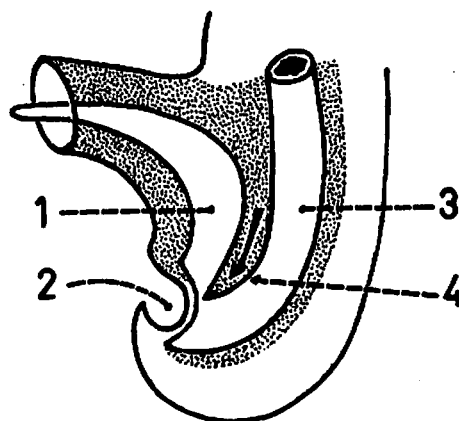


Fig.(176): DIVISION OF CLOACAL MEMBRANE
INTO UROGENITAL MEMBRANE
AND ANAL MEMBRANE

1. primitive urogenital sinus.
2. urogenital membrane.
3. primitive perineal body.
4. anal pit (proctodeum).
5. rectum and upper 1/2 of anal canal.
6. anal membrane.

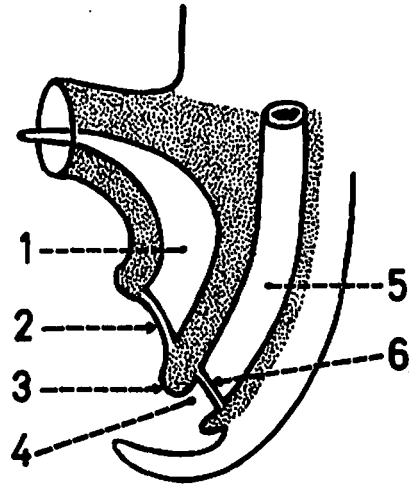
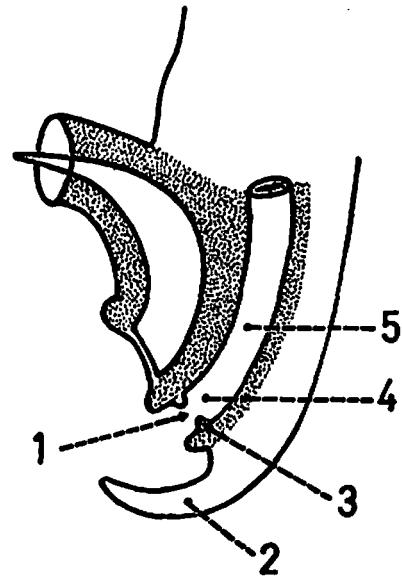


Fig.(177): RUPTURE OF ANAL MEMBRANE

1. ruptured anal membrane.
2. caudal end of the foetus (coccygeal segments).
3. remnant of anal membrane.
4. upper 1/2 of anal canal.
5. rectum.



ANOMALIES OF HINDGUT

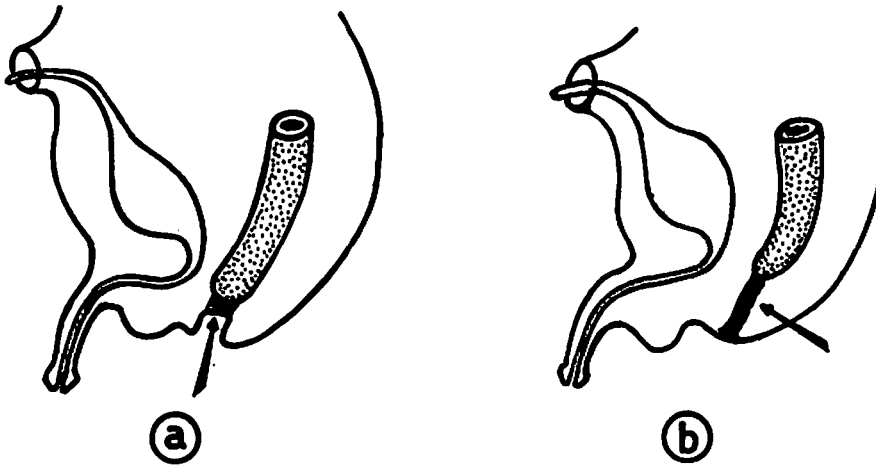


Fig.(178): FAILURE OF CANALIZATION

(a) Imperforate anus (persistence of anal membrane)

(b) Rectal atresia (failure of development)



Fig.(179): FISTULA FORMATION

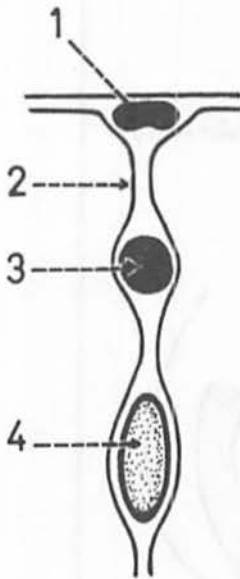
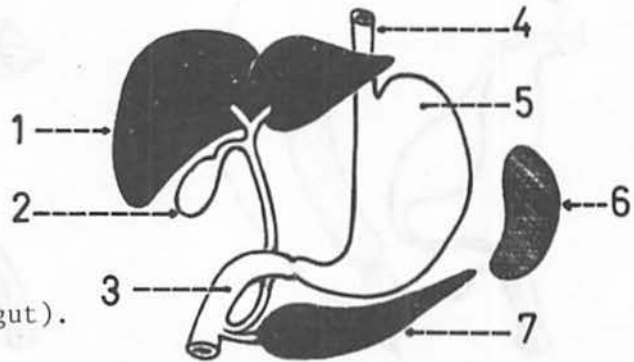
(a) Rectovaginal fistula

(b) Rectovesical fistula

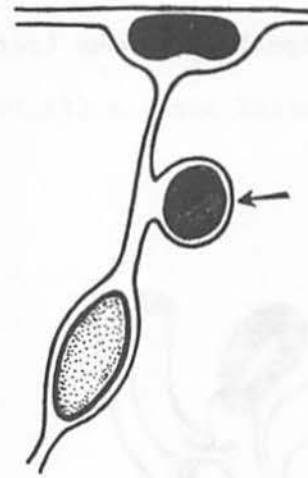
SPLEEN, LIVER AND PANCREAS

Fig.(180): DERIVATIVES OF THE FOREGUT

1. liver.
2. gall bladder.
3. upper 1/2 of duodenum.
4. oesophagus.
5. stomach.
6. spleen (not a part of foregut).
7. pancreas.



(a)



(b)

Fig.(181): DEVELOPMENT OF THE SPLEEN

(a) Early stage (mass of mesoderm in dorsal mesogastrium):

1. left kidney.
2. lienorenal ligament.
3. spleen.
4. stomach.

(b) Bulging of the spleen through the left layer of the dorsal mesogastrium.

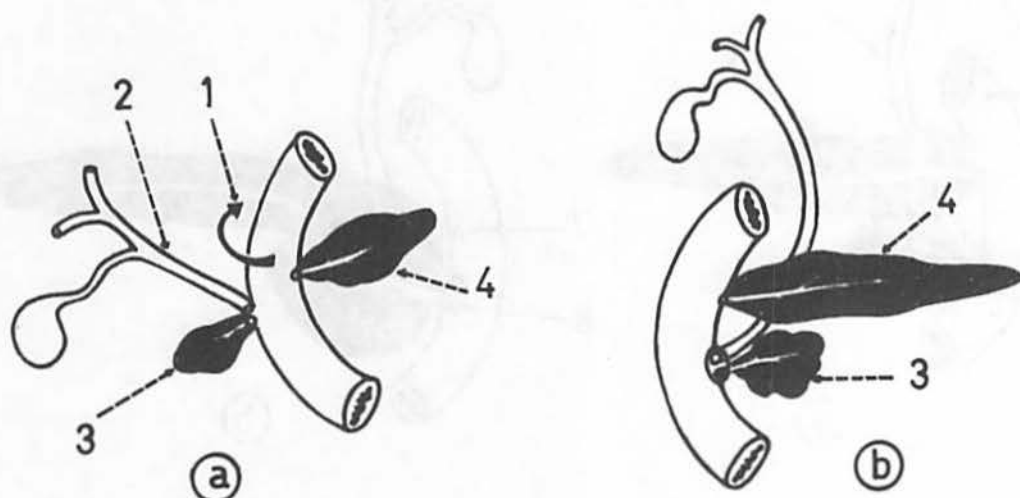


Fig.(182): DEVELOPMENT OF PANCREATIC BUDS

(a) Ventral and dorsal pancreatic buds
(before migration of the ventral bud)

(b) After migration of the ventral bud

1. direction of migration along the right side of duodenum.
2. stalk of hepatic bud.
3. ventral pancreatic bud or diverticulum (arises from the ventral aspect of duodenum).
4. dorsal pancreatic bud (arises from the dorsal aspect of duodenum and lies in the mesoduodenum).

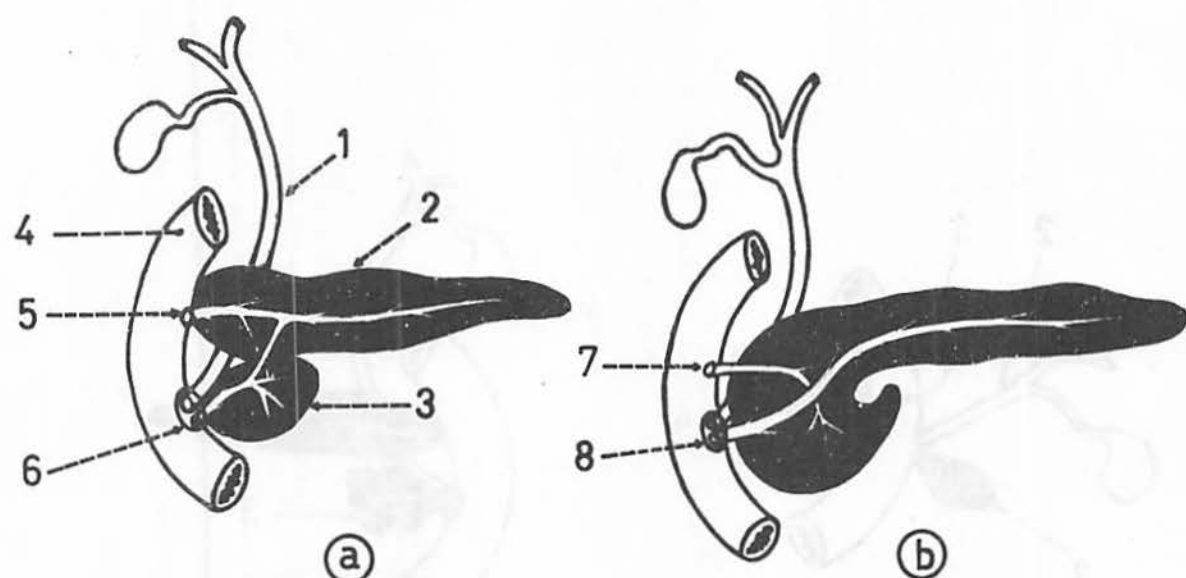


Fig.(183): DEVELOPMENT OF PANCREATIC DUCTS

(a) Early stage: anastomosis between ducts of the two buds.

(b) Advanced stage: formation of the main and accessory pancreatic ducts.

1. bile duct.
2. dorsal pancreatic bud (forms distal part of the main duct and proximal part of the accessory duct).
3. ventral pancreatic bud (forms proximal part of the main duct).
4. duodenum.
5. opening of the duct of dorsal bud.
6. opening of the duct of ventral bud together with the bile duct.
7. opening of the accessory duct (derived from proximal part of the duct of dorsal bud).
8. opening of the main duct (derived from the whole duct of ventral bud and distal part of the duct of dorsal bud).

Fig.(184): ANNULAR PANCREAS

The pancreatic tissue forms a ring around the whole circumference of the duodenum.

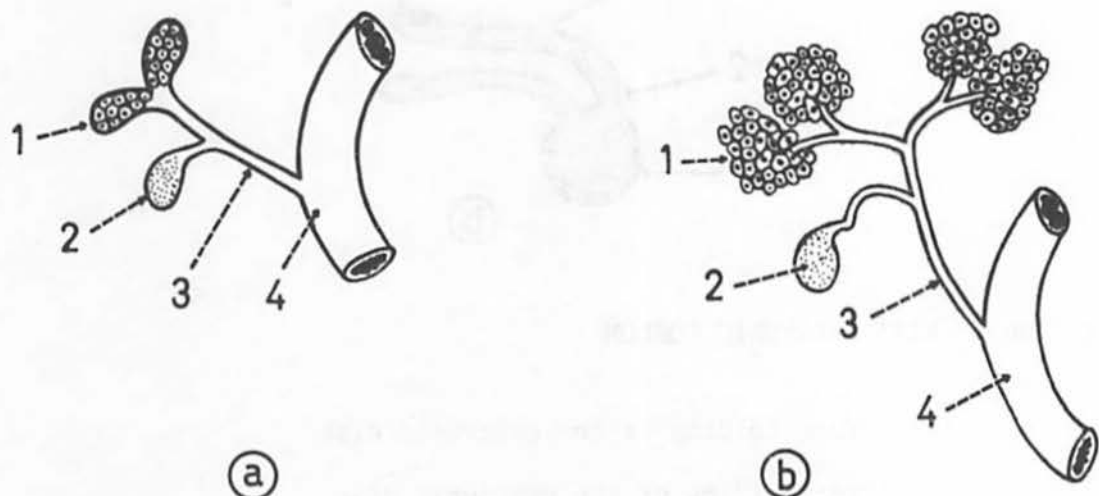


Fig.(185): DEVELOPMENT OF THE LIVER

- (a) Early stage: hepatic bud or diverticulum.
 (b) Advanced stage: formation of hepatic cells.

1. pars hepatica (forms liver cells).
2. pars cystica (forms gall bladder).
3. stalk of hepatic diverticulum (forms bile duct).
4. duodenum.

COELOMIC CAVITIES AND DIAPHRAGM

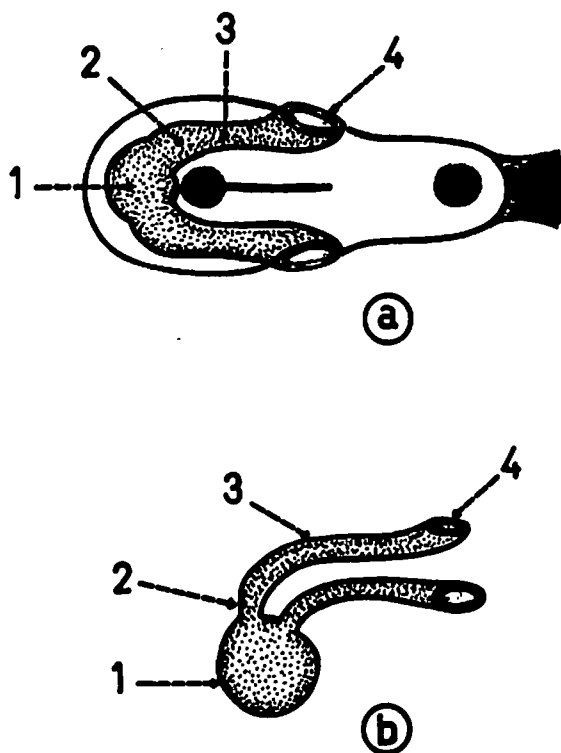


Fig.(186): INTRA-EMBRYONIC COELOM

(a) Before folding of the embryonic disc

(b) After folding of the embryonic disc

1. pericardial cavity.
2. primitive pleural cavity.
3. coelomic duct (primitive peritoneal cavity).
4. communication with the extra-embryonic coelom.

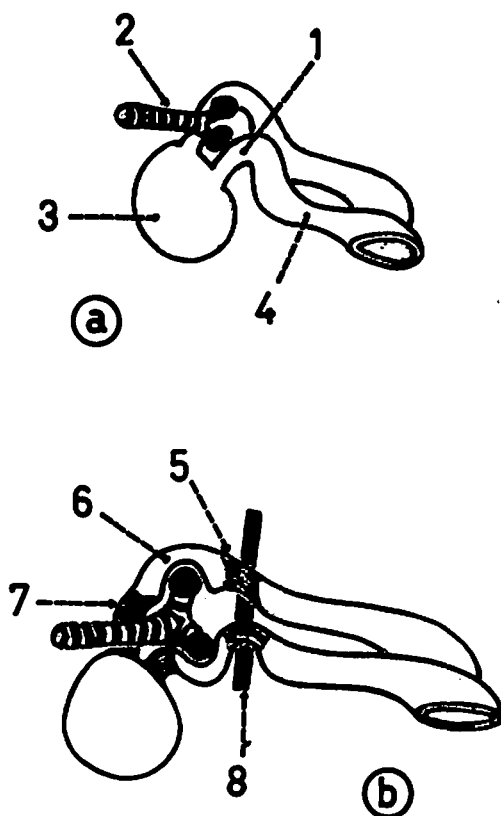


Fig.(187): DEVELOPMENT OF PLEURAL CAVITIES

(a) Early stage (not invaginated)

(b) Invagination by lung buds and formation of
pleuro-pericardial and pleuro-peritoneal membranes

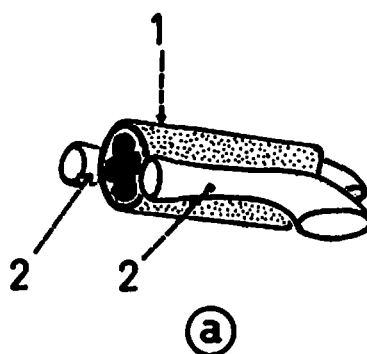
1. primitive pleural cavity.
2. trachea.
3. pericardial cavity.
4. coelomic duct.
5. pleuro-peritoneal membrane.
6. definitive pleural cavity.
7. pleuro-pericardial membrane.
8. edge of diaphragm.

N.B.: The pleuro-peritoneal canals traverse the diaphragm, one on each side.

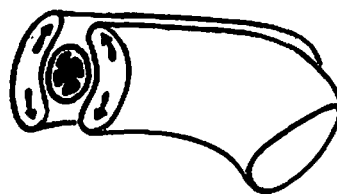
Fig.(188): DEVELOPMENT OF PERITONEAL CAVITY

(a) Early stage:(coelomic ducts, one on each side of the gut)

- 1. gut.
- 2. coelomic duct.

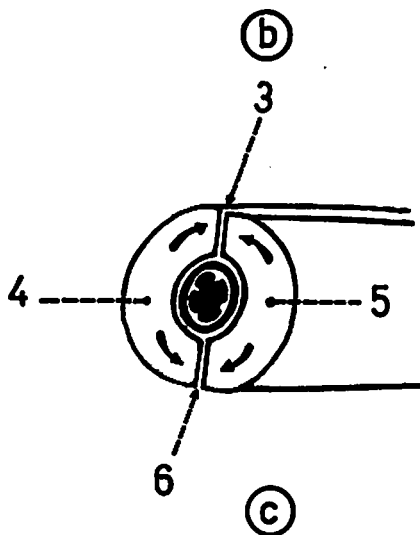


(b) Expansion of coelomic ducts



(c) Formation of dorsal and ventral mesenteries (for foregut)

- 3. dorsal mesentery.
- 4. right 1/2 of peritoneal cavity.
- 5. left 1/2 of peritoneal cavity.
- 6. ventral mesentery.



(d) Formation of dorsal mesentery (for midgut and hindgut)

- 7. dorsal mesentery of midgut or hindgut.
- 8. single peritoneal cavity.

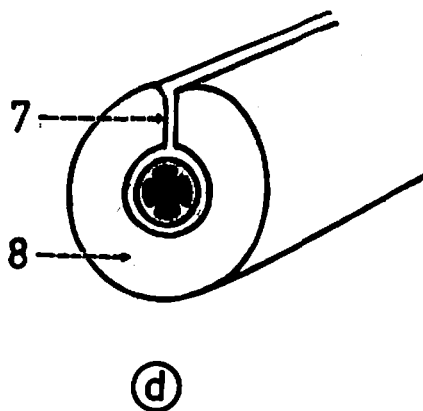


Fig.(189): VENTRAL AND DORSAL
MESENTERIES OF THE GUT

1. ventral mesogastrium.
2. vitello-intestinal duct.
3. umbilical orifice.
4. midgut loop.
5. dorsal mesentery.
6. hindgut.

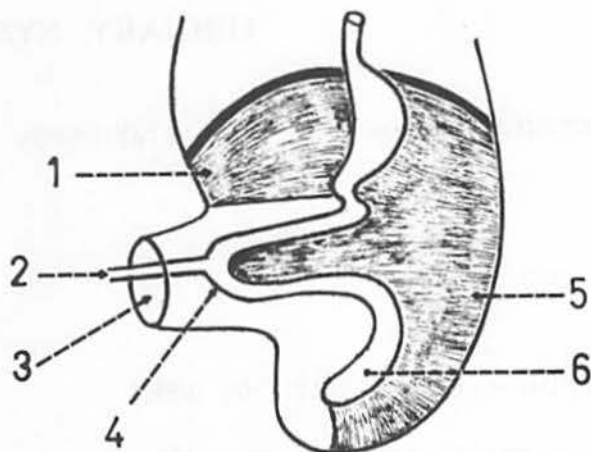


Fig.(190): DEVELOPMENT OF DIAPHRAGM

1. area derived from septum transversum and 3,4,5 cervical myotomes.
2. area derived from chest wall.
3. pleuro-peritoneal membrane.
4. dorsal mesentery of oesophagus.
5. dorsal aorta.
6. oesophagus.

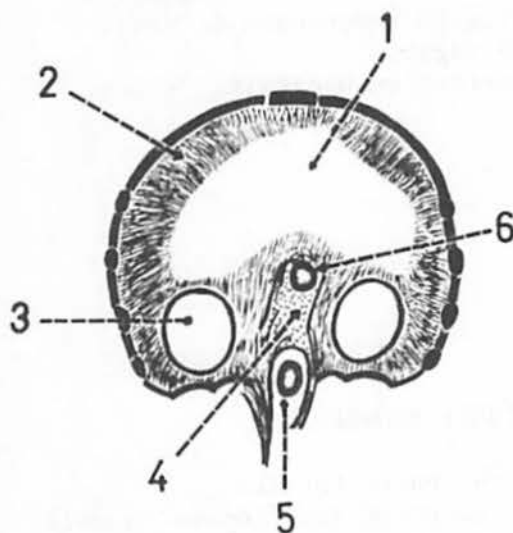
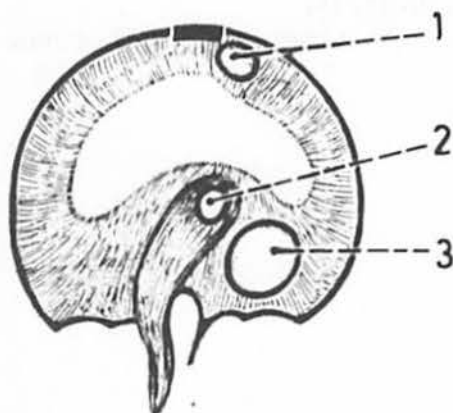


Fig.(191): SITES OF CONGENITAL
DIAPHRAGMATIC HERNIAE

1. hernia of Morgagni (between the sternal and costal origins).
2. hiatus hernia (through oesophageal opening).
3. hernia of Bochdalek (through left pleuro-peritoneal membrane).



URINARY SYSTEM

PRONEPHROS, MESONEPHROS AND METANEPHROS

Fig.(192): INTERMEDIATE MESODERM

1. cranial segmented pronephric region.
2. caudal longer non-segmented region (nephrogenic cord).
3. hindgut.
4. primitive urogenital sinus.

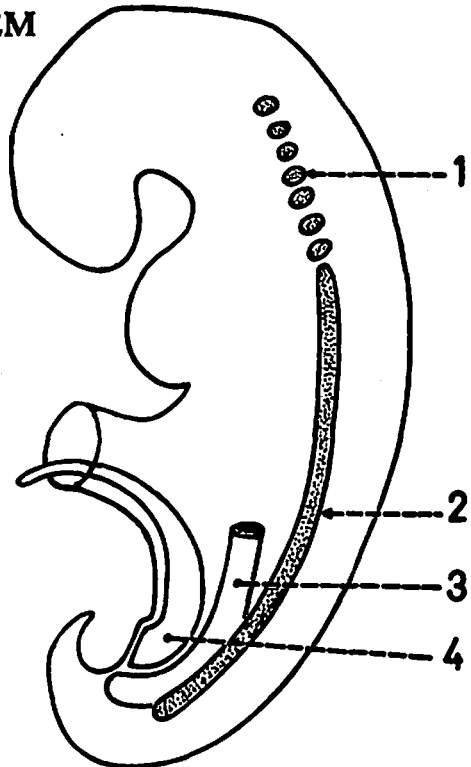


Fig.(193): PRONEPHROS

1. pronephric tubules.
2. pronephric duct (opens caudally into the urogenital sinus).
3. caudal part of nephrogenic cord.
4. hindgut.
5. primitive urogenital sinus.

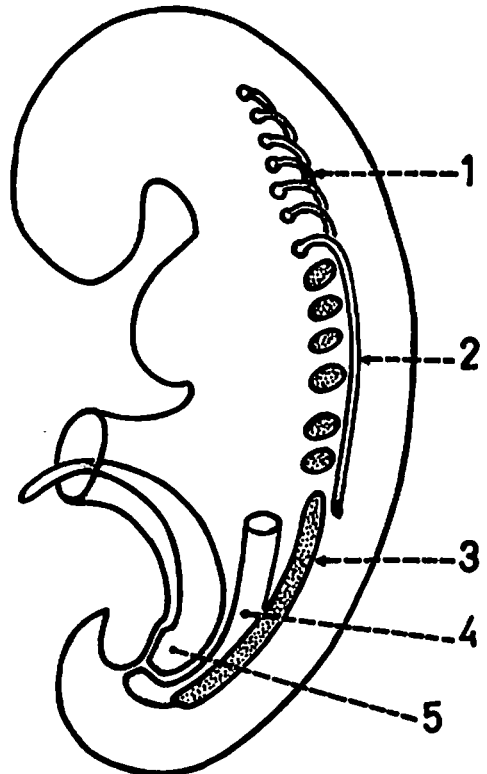


Fig.(194): MESONEPHROS

1. gonad (testis or ovary).
2. primitive urogenital sinus.
3. degenerated pronephros.
4. mesonephric tubule.
5. mesonephric (Wolffian) duct (it is the pronephric duct).
6. caudal part of nephrogenic cord (gives rise to metanephros).

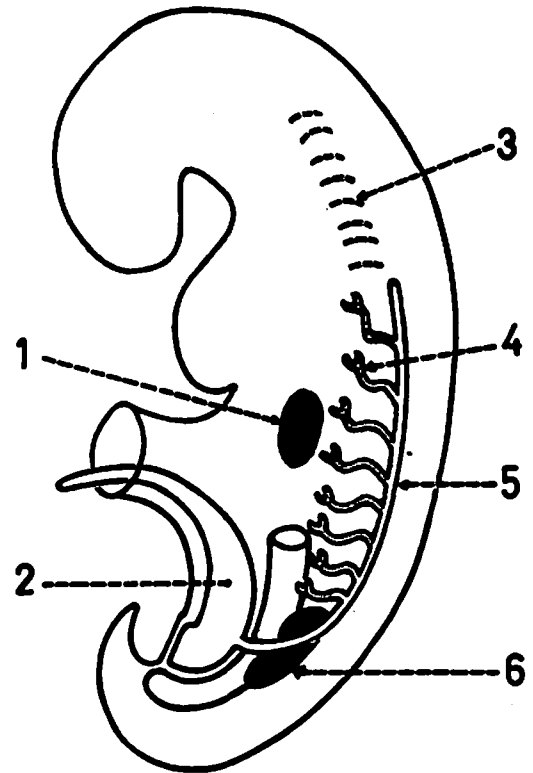
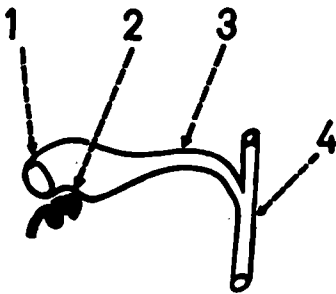


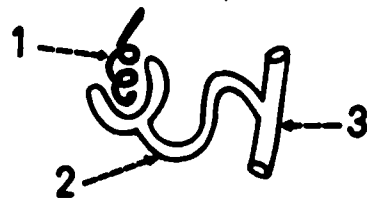
Fig.(195): PRONEPHRIC AND MESONEPHRIC TUBULES



(a)

(a) Pronephric tubule:

1. medial end (opens into coelomic cavity).
2. external glomerulus.
3. lateral end (joins pronephric duct).
4. pronephric duct.



(b)

(b) Mesonephric tubule:

1. internal glomerulus.
2. S-shaped tubule.
3. mesonephric duct.

N.B.: The medial end of the mesonephric tubule is blind and cup-shaped.

Fig.(196): FATE OF MESONEPHROS IN THE MALE

1. testis.
2. efferent ductules (vasa efferentia).
3. appendix of epididymis.
4. epididymis.
5. paradidymis.
6. aberrant ductules.
7. ductus deferens.
8. seminal vesicle.
9. ejaculatory duct.

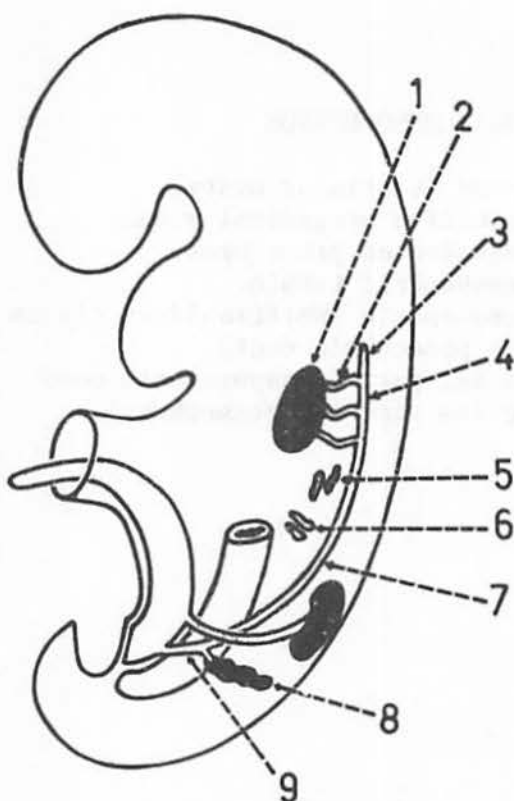


Fig.(197): FATE OF MESONEPHROS IN THE FEMALE

1. ovary.
2. primitive urogenital sinus.
3. epoophoron.
4. paroophoron.
5. degenerated mesonephric duct.
6. ureter.
7. rectum.

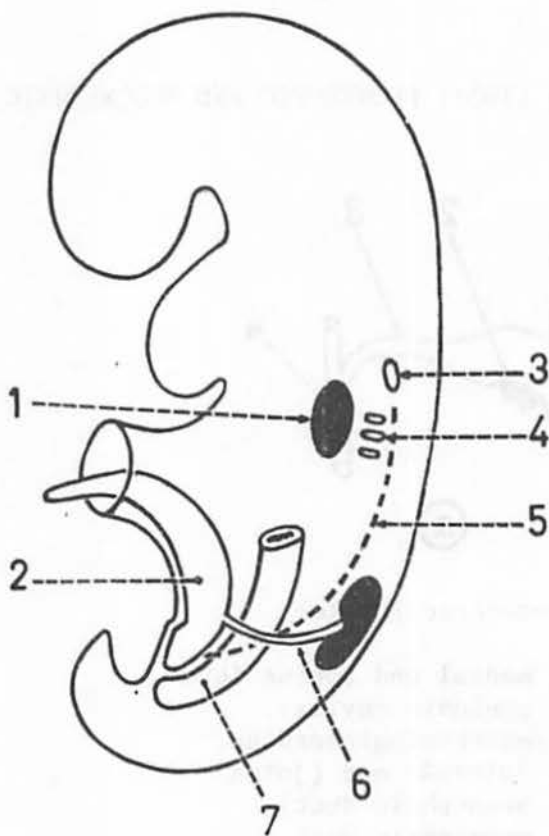


Fig.(198): METANEPHROS

- (a) Degeneration of mesonephros and appearance of metanephros
- (b) Both ureter and mesonephric duct opening separately into urogenital sinus

- 1. gonad.
- 2. urogenital sinus.
- 3. degenerated mesonephros.
- 4. mesonehric duct.
- 5. metanephros (metanephric cap and ureteric bud).
- 6. rectum.
- 7. mesonephric duct.
- 8. ureter opening separately into the urogenital sinus.

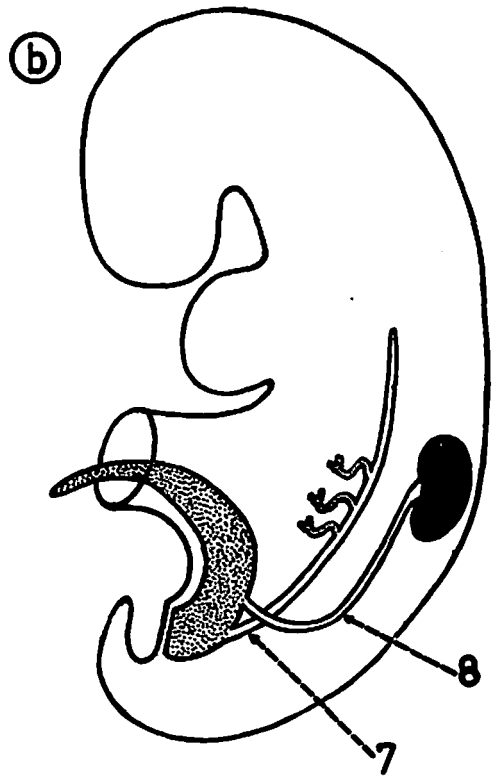
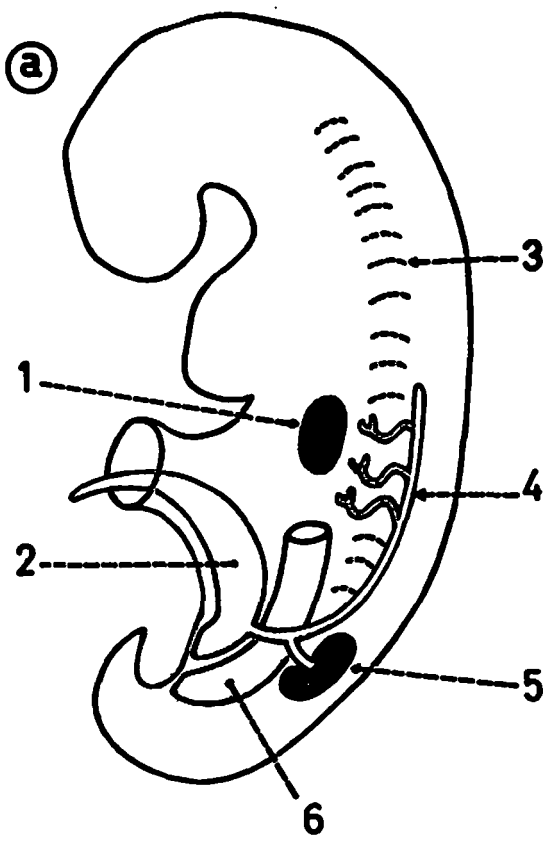


Fig.(199): ASCENT OF METANEPHROS

1. suprarenal gland (at its normal position).
2. vertebral column.
3. metanephros.

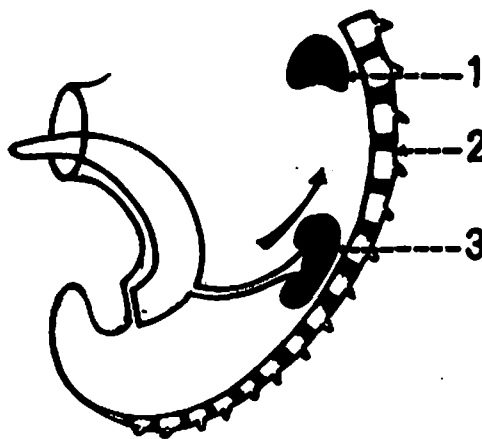


Fig.(200): DERIVATIVES OF URETERIC BUD

1. collecting tubules.
2. minor calyces.
3. pelvis of ureter and major calyces.
4. ureter.

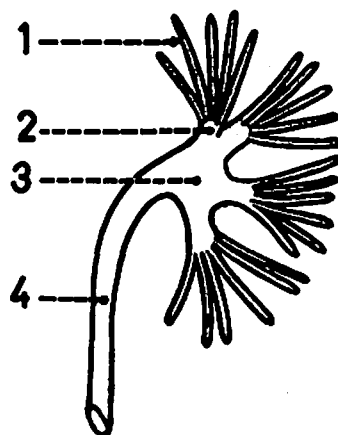


Fig.(201): DIVISION OF METANEPHRIC CAP INTO SMALL CAPS

1. collecting tubules.
2. small metanephric caps.
3. ureter.

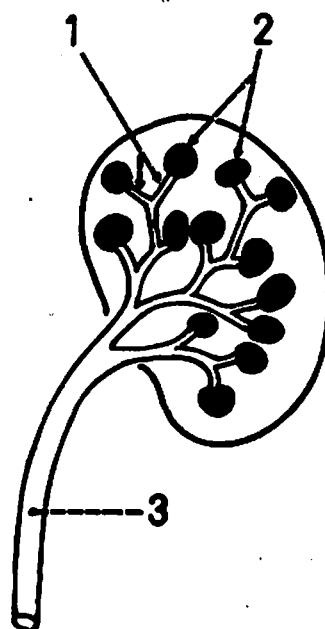
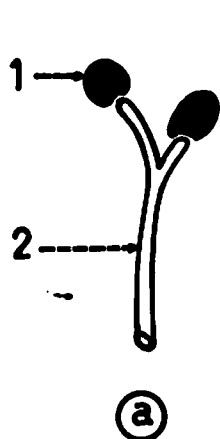
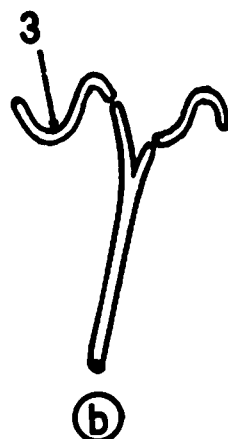


Fig.(202): DIFFERENTIATION OF METANEPHRIC TUBULE



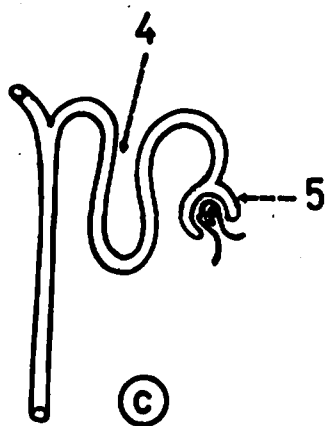
(a) Solid mass of metanephric cap

1. small metanephric cap.
2. collecting tubule.



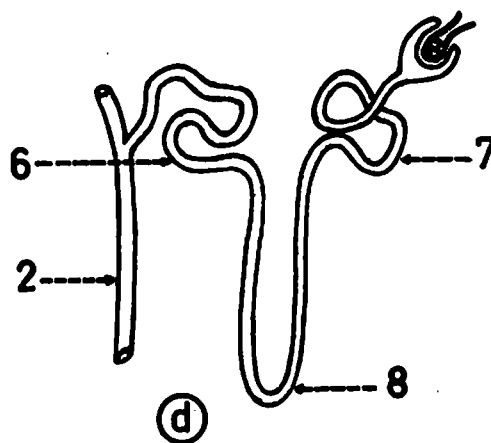
(b) S-shaped metanephric tubule (with two blind ends)

3. S-shaped metanephric tubule.



(c) Formation of renal corpuscle (with internal glomerulus)

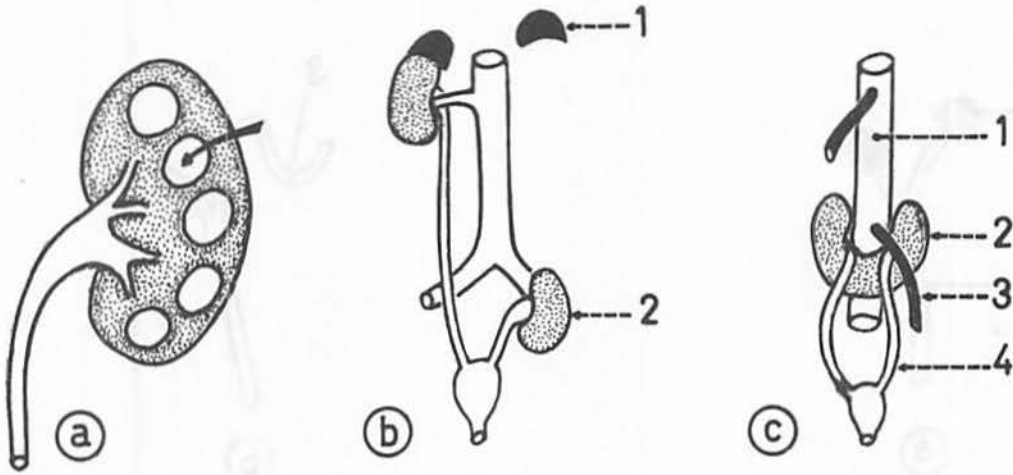
4. more convoluted tubule with its medial end connected with the collecting tubule.
5. renal corpuscle.



(d) COMPLETE NEPHRON

6. distal convoluted tubule.
7. proximal convoluted tubule.
8. loop of Henle.

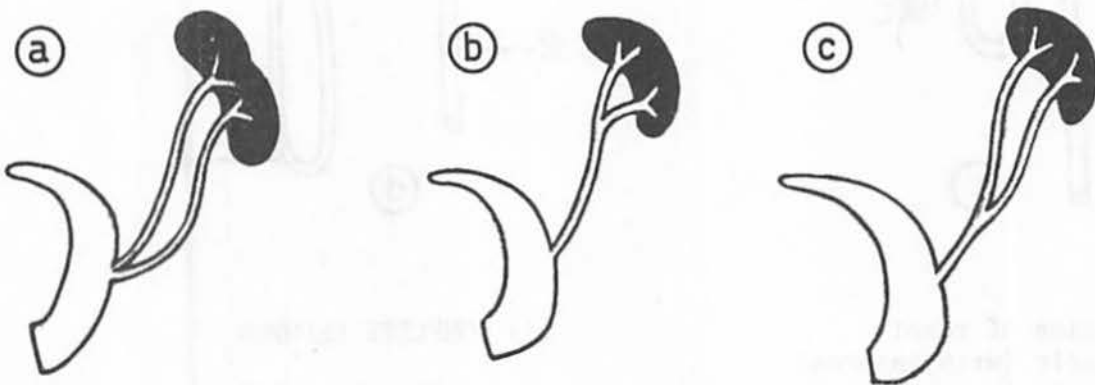
Fig.(203): ANOMALIES OF KIDNEY



(a) Polycystic kidney (b) Pelvic kidney:
 1. left suprarenal.
 2. pelvic kidney.

(c) Horse-shoe kidney:
 1. aorta.
 2. horse-shoe kidney.
 3. inferior mesenteric
 artery.
 4. ureter.

Fig.(204): ANOMALIES OF URETER



(a) Double ureter (b) Cleft renal pelvis (c) Bifid ureter

URINARY BLADDER AND URETHRA

Fig.(205): PRIMITIVE UROGENITAL SINUS

1. allantois.
2. vesico-urethral canal (the part above the mesonephric ducts).
3. pelvic part of urogenital sinus.
4. phallic part of urogenital sinus.
5. urogenital membrane.
6. mesonephric duct.
7. rectum.

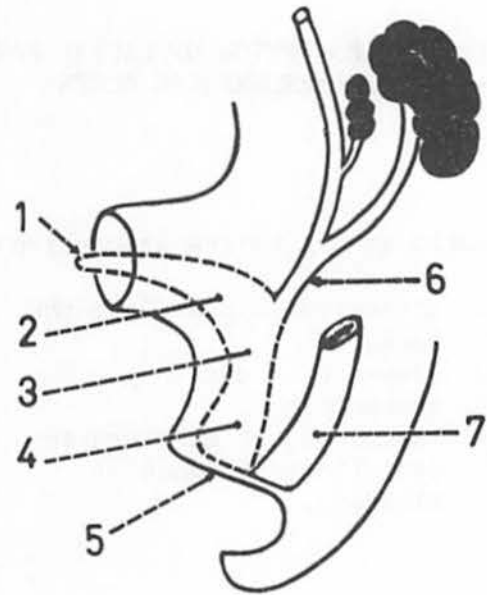


Fig.(206): FORMATION OF URINARY BLADDER

1. allantois.
2. vesico-urethral canal.
3. trigone of bladder.
4. phallic part of urogenital sinus.
5. urogenital membrane.
6. ureter.
7. seminal vesicle.
8. ejaculatory duct.

N.B.: The bladder develops from the vesico-urethral canal and absorbed parts of the two mesonephric ducts. The allantois is continuous with the apex of the bladder and forms the urachus.

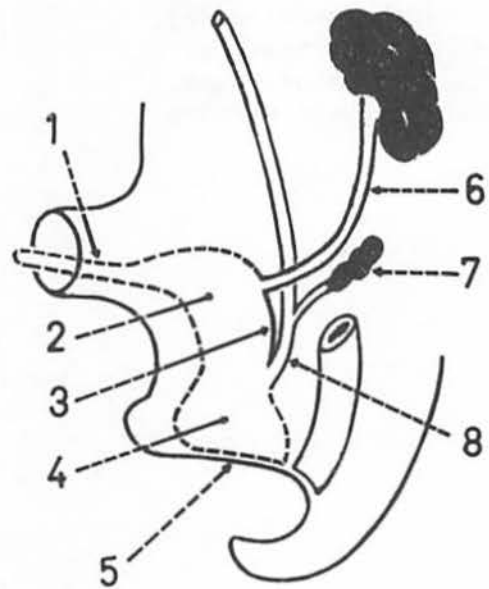
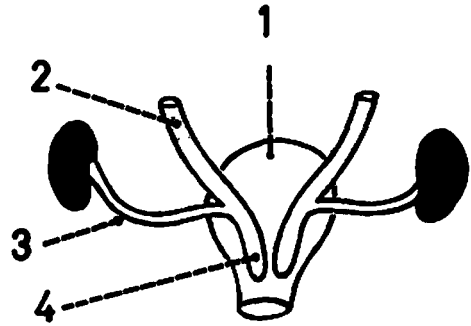


Fig.(207): ABSORPTION OF CAUDAL PARTS
OF MESONEPHRIC DUCTS

(a) Early stage (before absorption)

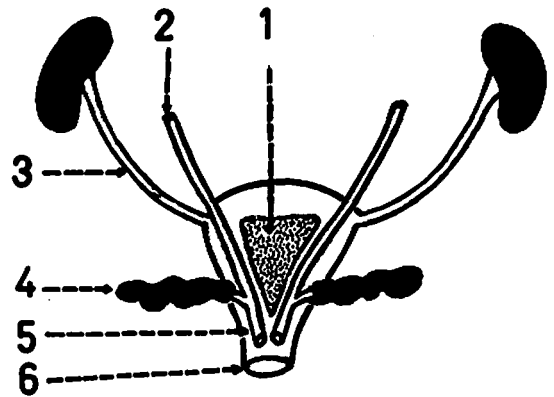
1. urogenital sinus (from the back).
2. mesonephric duct.
3. ureteric bud.
4. caudal end of mesonephric duct (forms trigone of bladder).



(a)

(b) After absorption

1. trigone.
2. mesonephric duct (becomes ductus deferens).
3. ureter (opens separately into the bladder).
4. seminal vesicle.
5. ejaculatory duct.
6. prostatic urethra.



(b)

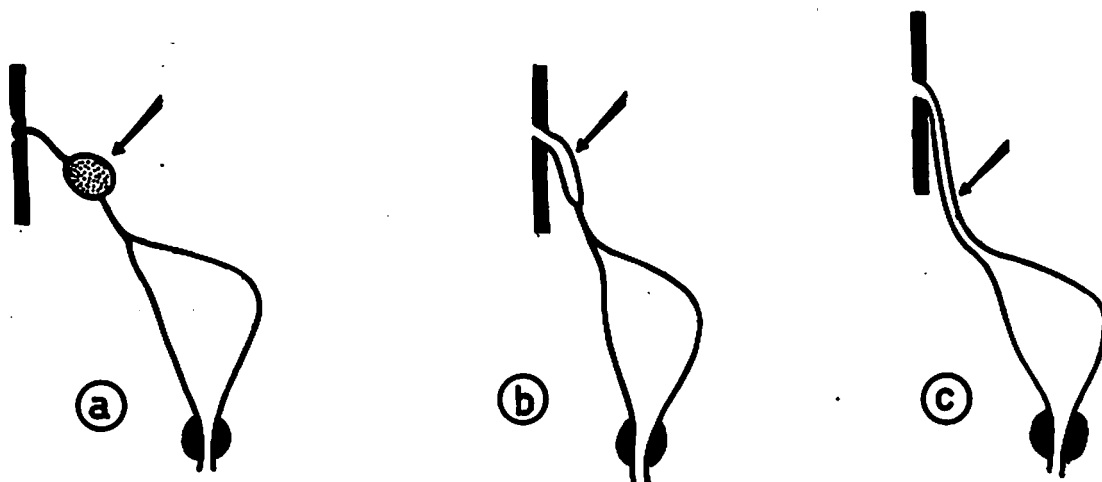


Fig.(208): ANOMALIES OF URACHUS

(a) Urachal cyst (patent isolated part).

(b) Urachal sinus (patent distal part).

(c) Urachal fistula (patent whole urachus).

N.B.: The urachus extends from the umbilicus to the apex of the bladder. Normally, it becomes fibrosed and is transformed into the median umbilical ligament.

Fig.(209): ECTOPIA VESICAE

1. anterior abdominal wall.
2. urinary bladder.
3. opening of the bladder just above the symphysis pubis.
4. symphysis pubis.

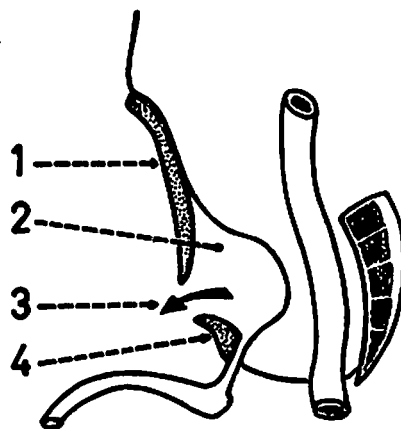
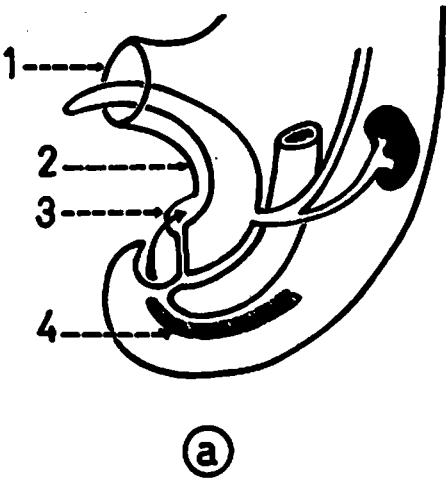


Fig.(210): FORMATION OF GENITAL
TUBERCLE AND INFRA-UMBILICAL
PART OF ANTERIOR ABDOMINAL
WALL

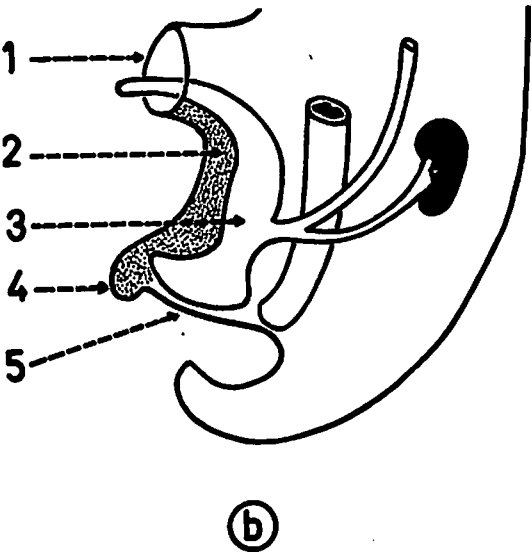
(a) Direction of spread of mesoderm
(from caudal end of primitive
streak to anterior abdominal wall)

- 1. umbilical orifice.
- 2. infra-umbilical part of
anterior abdominal wall.
- 3. genital tubercle.
- 4. primitive streak (caudal end).



(b) Advanced stage (after spread)

- 1. umbilical orifice.
- 2. mesoderm in infra-umbilical
part of anterior abdominal wall.
- 3. urinary bladder.
- 4. genital tubercle.
- 5. urogenital membrane.



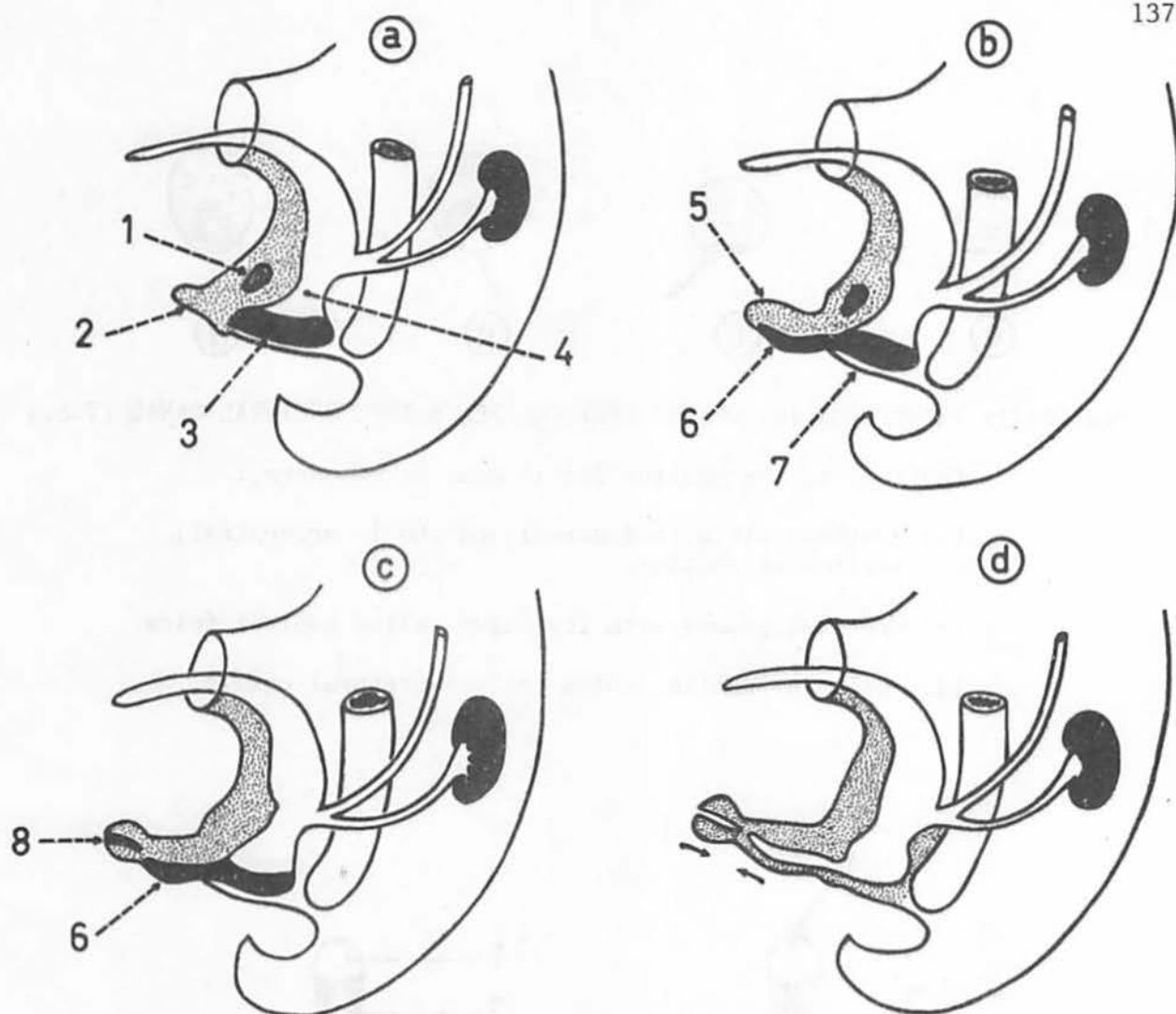


Fig.(211): DEVELOPMENT OF PENILE URETHRA

- (a) Proliferation of endoderm lining pelvic part of definitive urogenital sinus.
- (b) Formation of urethral plate on the under surface of phallus.
- (c) Extension of a cord of ectodermal cells in the glans penis.
- (d) Canalization of the penile urethra and then communication between its two parts.

- 1. symphysis pubis.
- 2. phallus.
- 3. phallic part of definitive urogenital sinus (solid mass of endodermal cells).
- 4. pelvic part of definitive urogenital sinus.
- 5. penis.
- 6. urethral plate.
- 7. urogenital membrane.
- 8. ectodermal cord within the glans penis (from surface ectoderm).

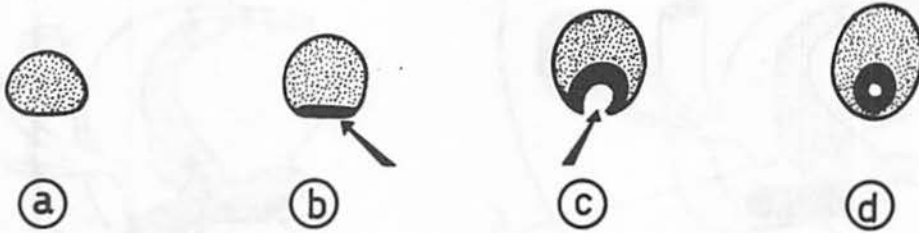


Fig.(212): TRANSFORMATION OF THE URETHRAL PLATE INTO URETHRAL CANAL (T.S.)

- (a) T.S. in the phallus (solid mass of mesoderm).
- (b) Urethral plate (endodermal) on the lower(ventral) surface of phallus.
- (c) Urethral groove with its edges called genital folds.
- (d) Fusion of genital folds to form urethral canal.

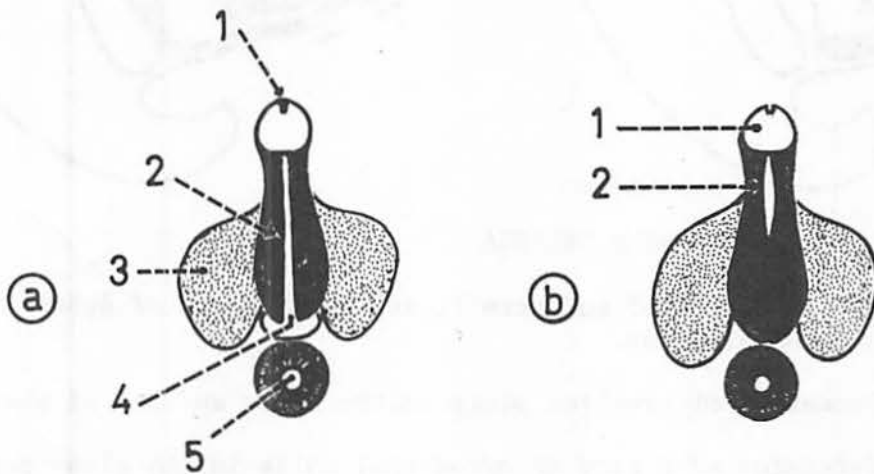


Fig.(213): FUSION OF URETHRAL GROOVE
(on ventral surface of the penis)

- (a) Urethral groove (completely open)
- (b) Fusion of urethral groove

- 1. glans penis (with growing cord of ectodermal cells).
- 2. lip of urethral groove (genital fold).
- 3. scrotum.
- 4. urethral groove.
- 5. anal orifice.

ANOMALIES OF THE URETHRA

Fig.(214): EPISPADIUS

(The urethra opens on the dorsum of penis, close to its root).

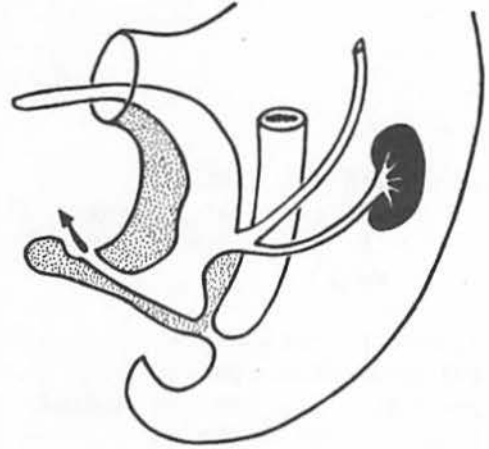


Fig.(215): HYPOSPADIUS

(The urethra opens on the ventral surface of penis).

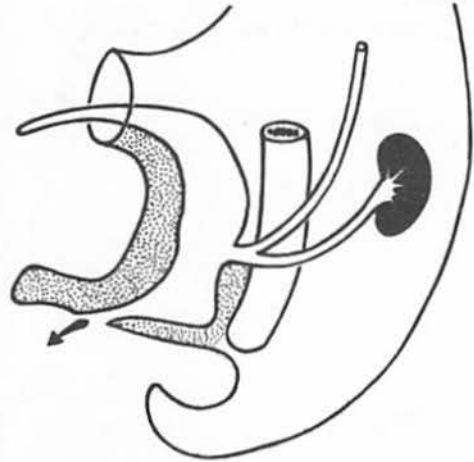
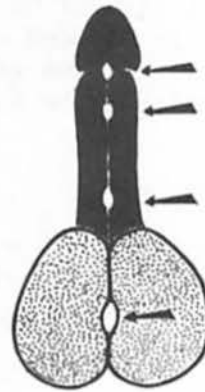


Fig.(216): SITES OF HYPOSPADIUS ON THE VENTRAL SURFACE OF PENIS



GENITAL SYSTEM

Fig.(217): GENITAL RIDGES
(as seen projecting from
the posterior abdominal
wall)

1. urogenital mesentery.
2. bulge of mesonephros.
3. genital ridge (on the medial aspect of mesonephros).
4. gut and its mesentery.
5. aorta.
6. coelomic cavity.

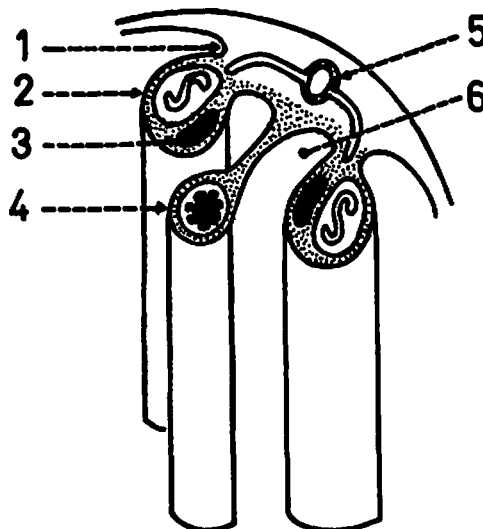


Fig.(218): COURSE OF MIGRATION OF
PRIMORDIAL SEX CELLS
(from caudal end of
yolk sac to the genital
ridge along the hindgut)

1. mesonephros.
2. genital ridge.
3. gut.
4. caudal end of yolk sac.

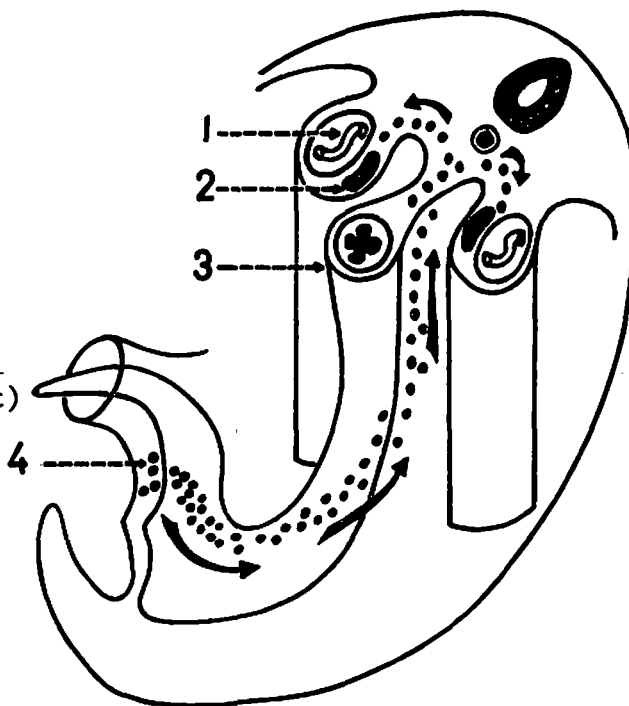
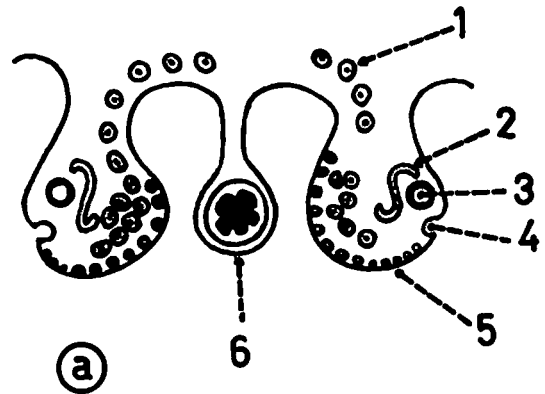


Fig.(219): DIFFERENTIATION OF
GENITAL RIDGE
(formation of gonad and
genital ducts)

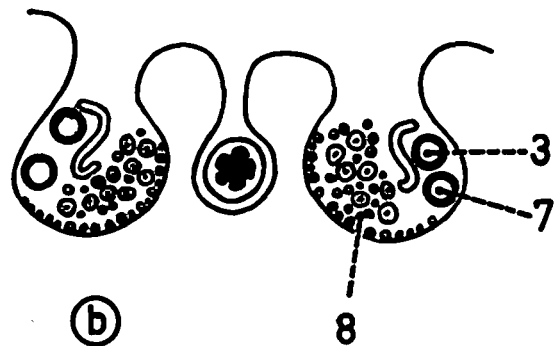
(a) Stage of migration of
primordial sex (germ) cells

1. primordial sex cells.
2. mesonephric tubule.
3. mesonephric duct.
4. invagination of
paramesonephric duct.
5. coelomic epithelium.
6. gut.



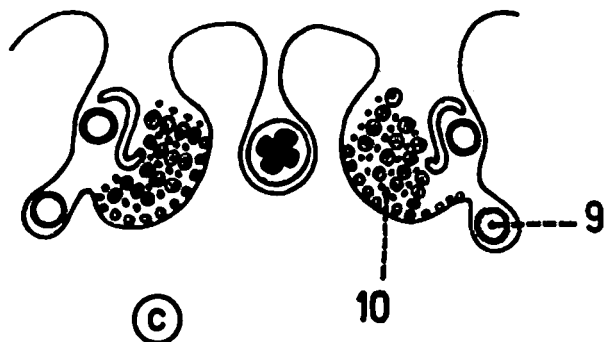
(b) Stage of indifferent gonad
(neither male nor female) and
formation of paramesonephric
duct.

7. paramesonephric duct.
8. indifferent gonad.



(c) Advanced stage: gonad with
sex cords and the para-
mesonephric duct is suspended
by peritoneal fold.

9. paramesonephric duct
suspended by a fold.
10. sex cords.

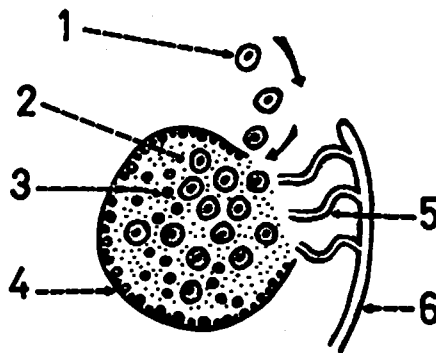


MALE GENITAL ORGANS

Fig.(220): DEVELOPMENT OF TESTIS

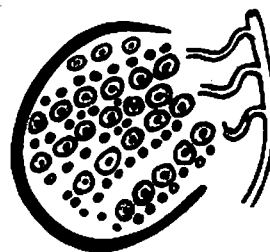
(a) Indifferent stage (neither male nor female)

1. primordial germ cells.
2. mesoderm of genital ridge.
3. mesothelial cells (from the coelomic epithelium).
4. coelomic epithelium.
5. mesonephric tubule.
6. mesonephric duct.



(a)

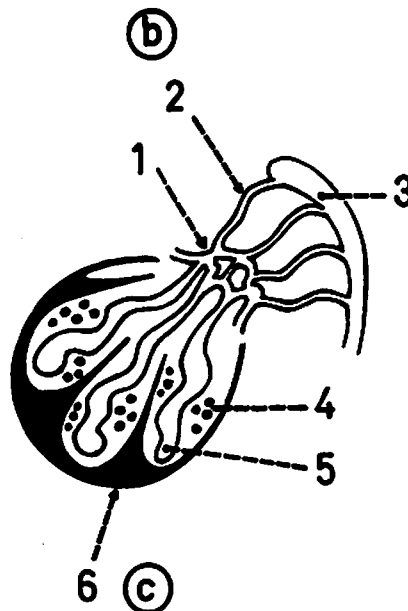
(b) Stage of testis cords



(b)

(c) Formation of seminiferous tubules

1. rete testis.
2. efferent ductules.
3. epididymis.
4. interstitial cells of Ledig.
5. seminiferous tubule.
6. fibrous septum.



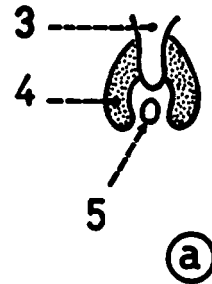
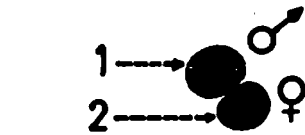
(c)

Fig.(221): HERMAPHRODITISM

(a) True hermaphroditism

(presence of male and female gonads as well as external genitalia of both sexes)

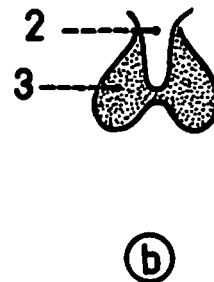
1. testis.
2. ovary.
3. penis.
4. labia majora.
5. rudimentary vagina.



(b) Female pseudohermaphroditism

(presence of ovary associated with male external genitalia)

1. ovary.
2. penis.
3. scrotum.



(c) Male pseudohermaphroditism

(presence of testis associated with female external genitalia)

1. testis.
2. clitoris.
3. labia majora.
4. vagina.

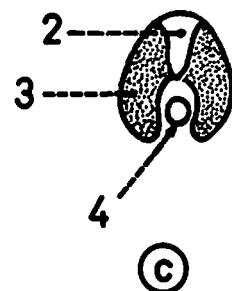


Fig.(222): DESCENT OF TESTIS

1. peritoneal cavity.
2. processus vaginalis.
3. scrotum.
4. testis in iliac fossa (by 3rd month).
5. testis in inguinal canal (by 7th month).
6. testis in scrotum (at birth).
7. Gubernaculum.

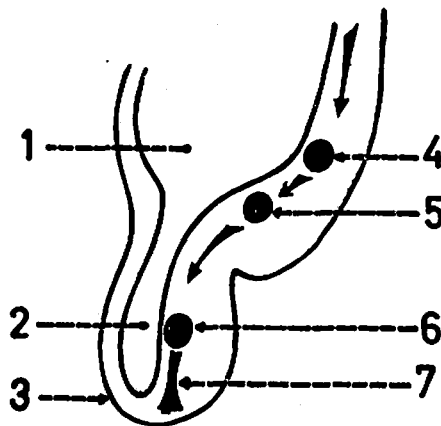


Fig.(223): ECTOPIC TESTIS
(the testis is kept away from its normal course)

1. at root of penis.
2. in perineum.
3. just above the superficial inguinal ring.
4. in upper part of medial side of thigh.

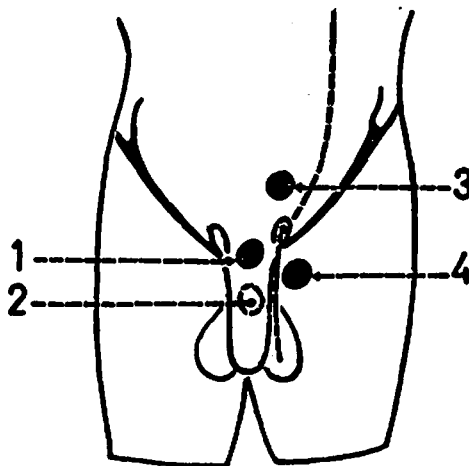


Fig.(224): UNDESCENDED TESTIS
(the testis is arrested along its normal course)

1. in abdominal cavity.
2. in inguinal canal.

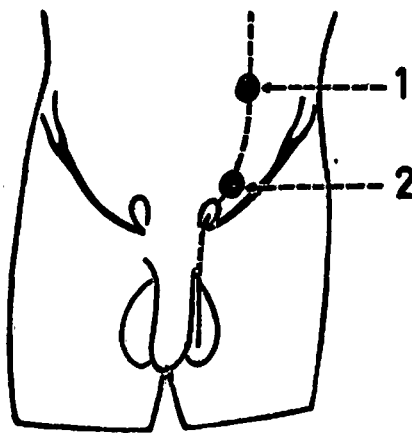
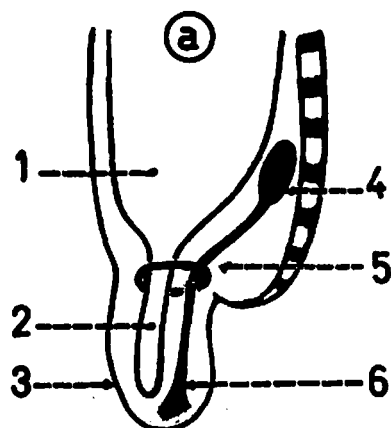


Fig.(225): DEVELOPMENT OF PROCESSUS VAGINALIS

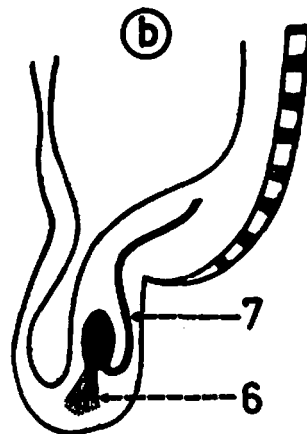
- (a) Early stage: descent of a pouch of peritoneum into the scrotum along with the gubernaculum.

1. coelomic (peritoneal) cavity.
2. processus vaginalis.
3. scrotum.
4. testis in abdomen.
5. inguinal canal.
6. gubernaculum.



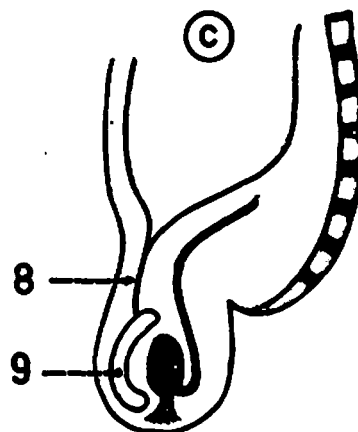
- (b) Descent of testis dragging with it the ductus deferens

7. ductus deferens.



- (c) Obliteration of part of processus vaginalis while its caudal end becomes tunica vaginalis

8. vestige of processus vaginalis.
9. tunica vaginalis.



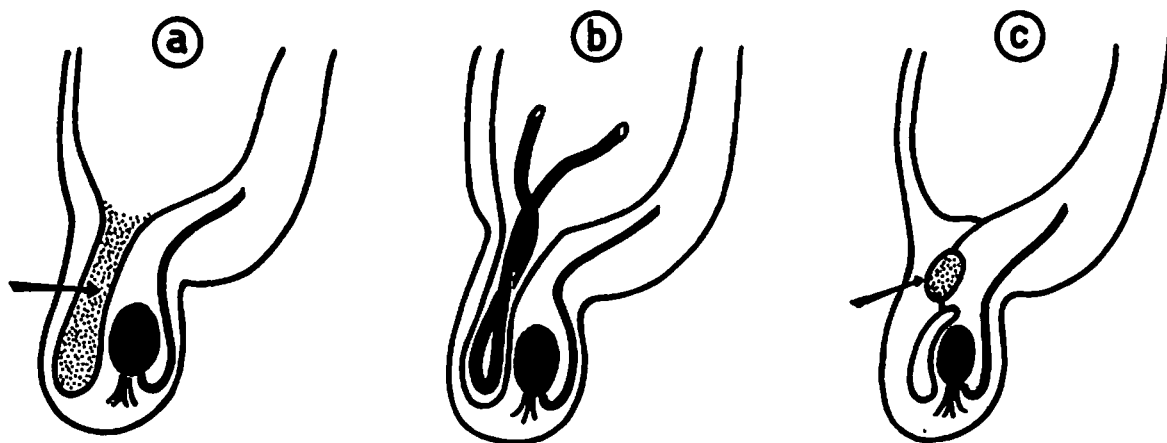


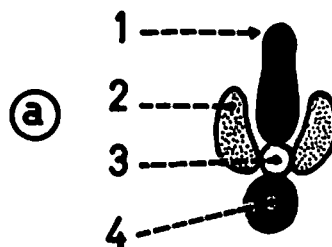
Fig.(226): ANOMALIES OF PROCESSUS VAGINALIS

- (a) Congenital hydrocele (filled with peritoneal fluid)
- (b) Congenital inguinal hernia (filled with loops of intestine)
- (c) Cyst formation (isolated part filled with fluid)

Fig.(227): EXTERNAL MALE GENITAL ORGANS

(a) Indifferent stage

- 1. phallus.
- 2. labio-scrotal swelling.
- 3. urogenital membrane.
- 4. anal orifice.



(b) Advanced stage

- 1. penis.
- 2. scrotum.
- 3. anal orifice.

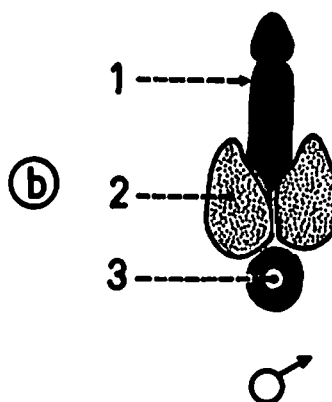
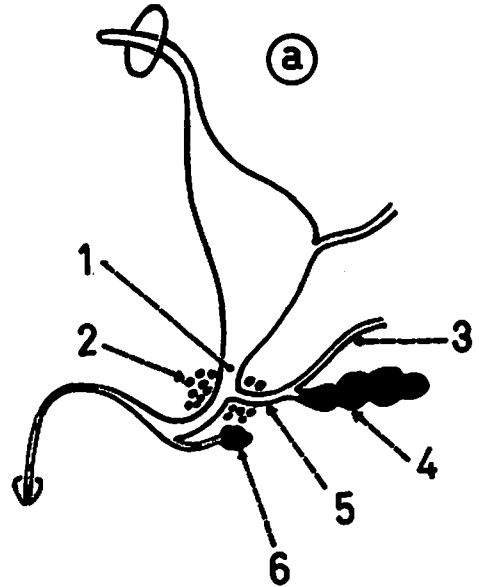


Fig.(228): PROSTATE, SEMINAL VESICLES AND
BULBO-URETHRAL GLANDS

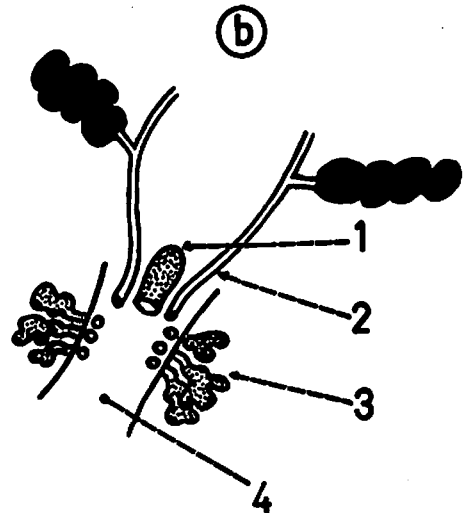
(a) Side view

1. prostatic urethra.
2. prostate.
3. ductus deferens.
4. seminal vesicle.
5. ejaculatory duct.
6. bulbo-urethral gland.



(b) Structures opening into
prostatic urethra

1. prostatic utricle (from
paramesonephric ducts).
2. ejaculatory duct (from
mesonephric duct).
3. prostate.
4. prostatic urethra.

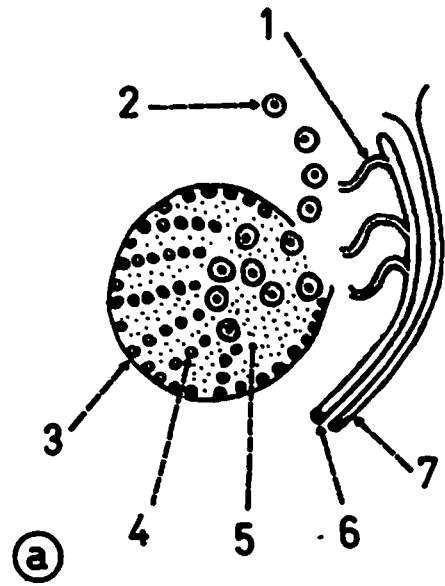


FEMALE GENITAL ORGANS

Fig.(229): DEVELOPMENT OF THE OVARY

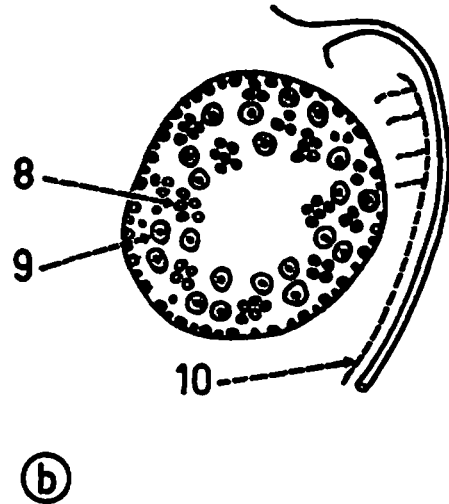
(a) Indifferent stage (neither male nor female)

1. mesonephric tubule.
2. primordial germ cells.
3. coelomic epithelium.
4. cords of mesothelial cells from coelomic epithelium.
5. mesoderm of genital ridge.
6. mesonephric duct.
7. paramesonephric duct.



(b) Stage of clusters of cells

8. clusters of follicular cells.
9. primordial germ cells
10. degenerated mesonephric duct.



(c) Stage of primordial follicles

11. primordial follicle (in the cortex of ovary).

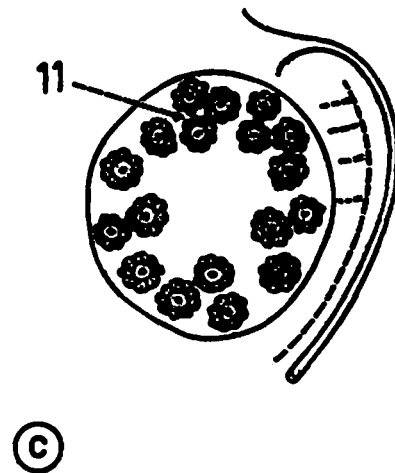
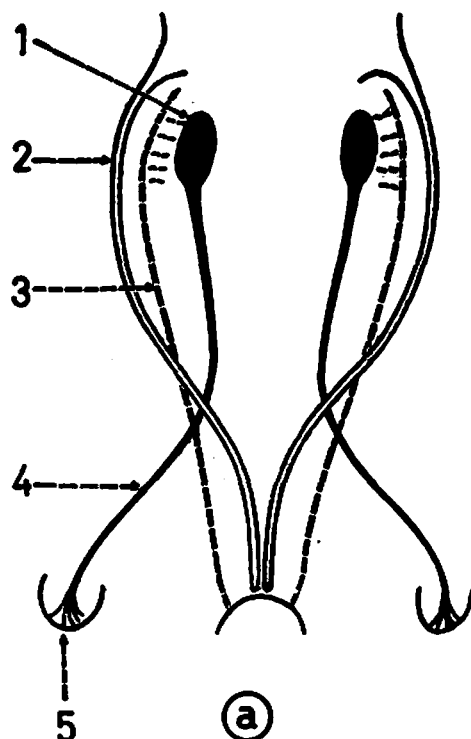


Fig.(230): DESCENT OF OVARY

(a) Early stage (before descent)

1. ovary.
2. paramesonephric (Muller's) duct
3. degenerated mesonephric duct.
4. gubernaculum.
5. labium majus.



(b) After descent

6. ovarian ligament.
7. fusion between paramesonephric duct and gubernaculum.
8. round ligament of uterus.

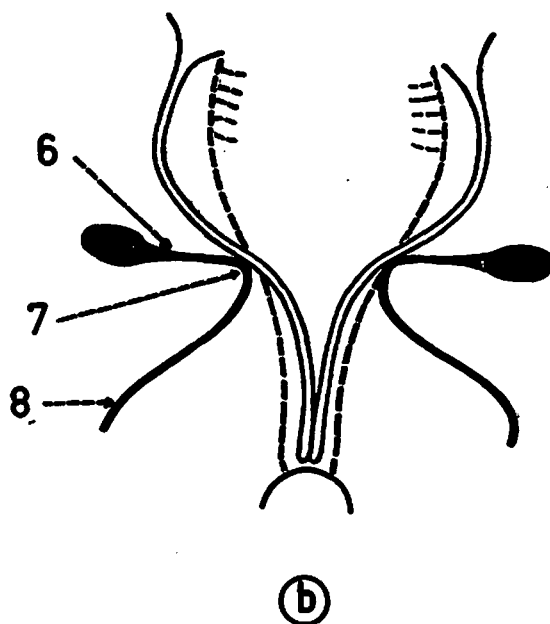
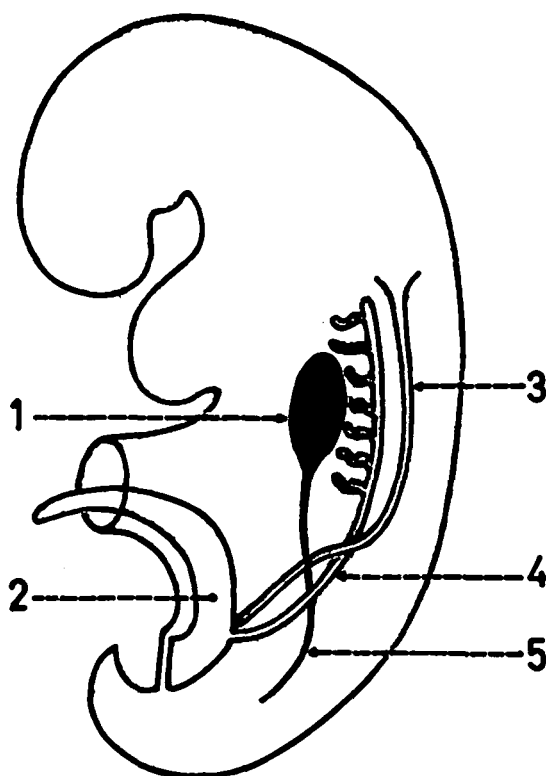


Fig.(231): COURSE OF MESONEPHRIC
AND 'PARAMESONEPHRIC DUCTS
(the two genital ducts)

(a) Side view

1. ovary.
2. urogenital sinus.
3. paramesonephric (Muller's)
duct (with open cranial
end and blind caudal end).
4. mesonephric (Wolffian)
duct (with open caudal end
and blind cranial end).
5. gubernaculum.



(b) Frontal view

1. funnel-shaped cranial end
of the paramesonephric
duct.
2. mesonephric duct.
3. cranial 1/3 of para-
mesonephric duct (lateral
to mesonephric duct).
4. intermediate 1/3 of
paramesonephric duct
(crosses ventral to
mesonephric duct).
5. caudal 1/3 of para-
mesonephric duct (medial
to mesonephric duct).
6. caudal blind end of
paramesonephric ducts
projecting against the
posterior wall of uro-
genital sinus to form
Mullerian tubercle.
7. Mullerian tubercle.
8. urogenital sinus.

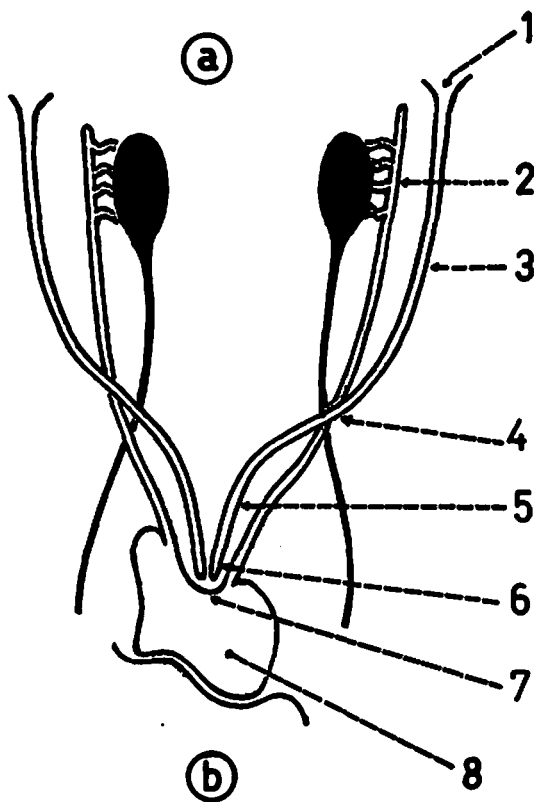


Fig.(232): GENITAL CORD
(cord of mesoderm around the
caudal parts of the two
paramesonephric ducts)

1. ovary.
2. degenerated mesonephric tubules.
3. cranial end of paramesonephric duct.
4. degenerated mesonephric duct.
5. gubernaculum.
6. genital cord of mesoderm.
7. urogenital sinus (endodermal).
8. Mullerian tubercle.

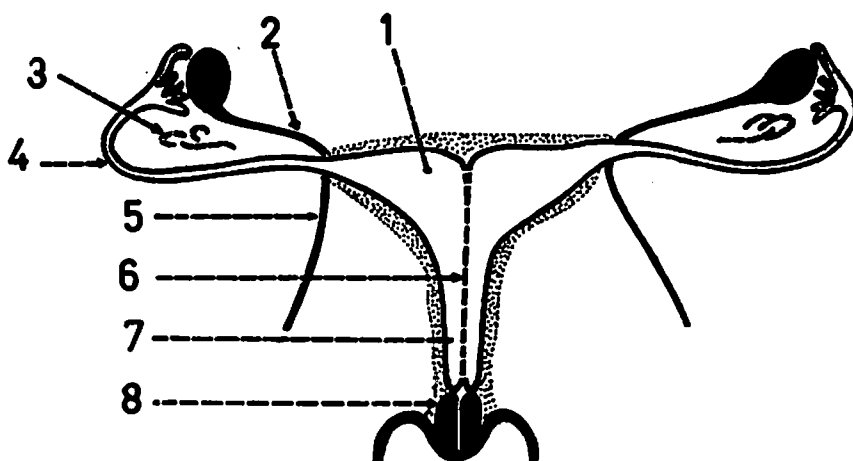
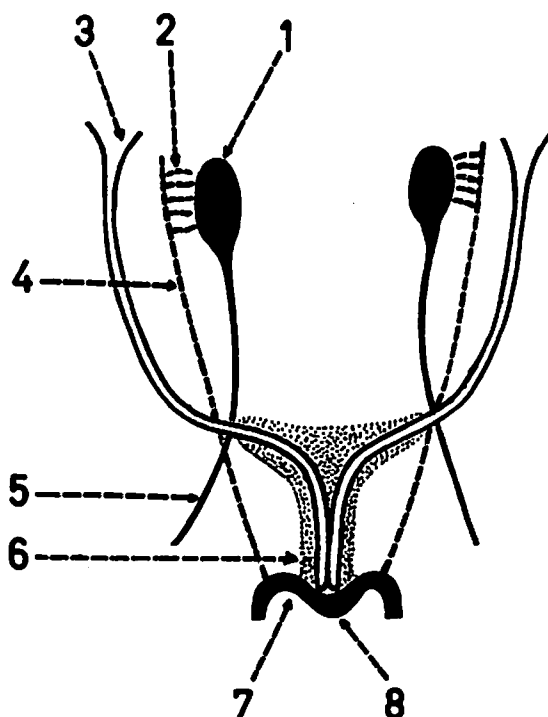


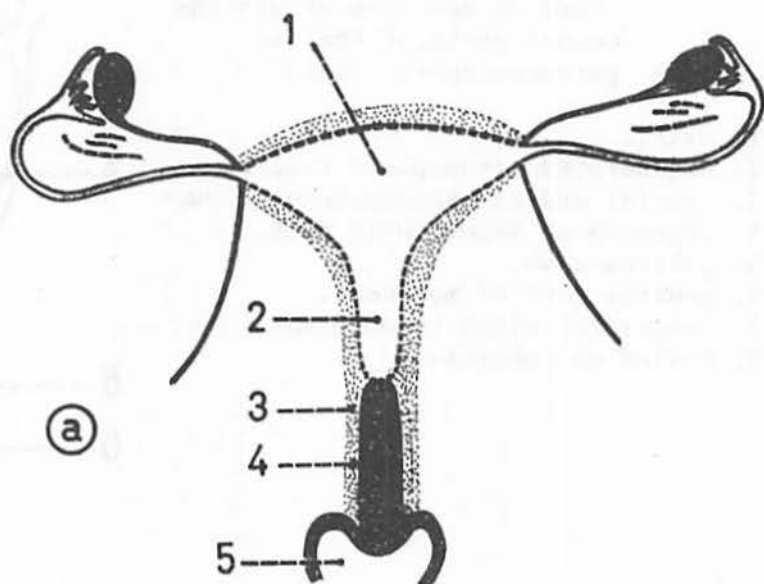
Fig.(233): DEVELOPMENT OF UTERUS

1. body of uterus.
2. ovarian ligament.
3. epoophoron and paroophoron.
4. uterine tube.
5. round ligament of uterus.
6. degenerated septum between the two paramesonephric ducts.
7. region of cervix.
8. sinu-vaginal bulbs (endodermal).

Fig.(234): DEVELOPMENT OF VAGINA

(a) Early stage

1. uterus.
2. cervix.
3. genital cord.
4. vaginal plate (from sinu-vaginal bulb).
5. urogenital sinus (endodermal).



(b) Advanced stage

1. cervix.
2. vaginal fornix.
3. vagina (endodermal lining).
4. hymen.
5. labium minor.
6. vestibule of vagina.

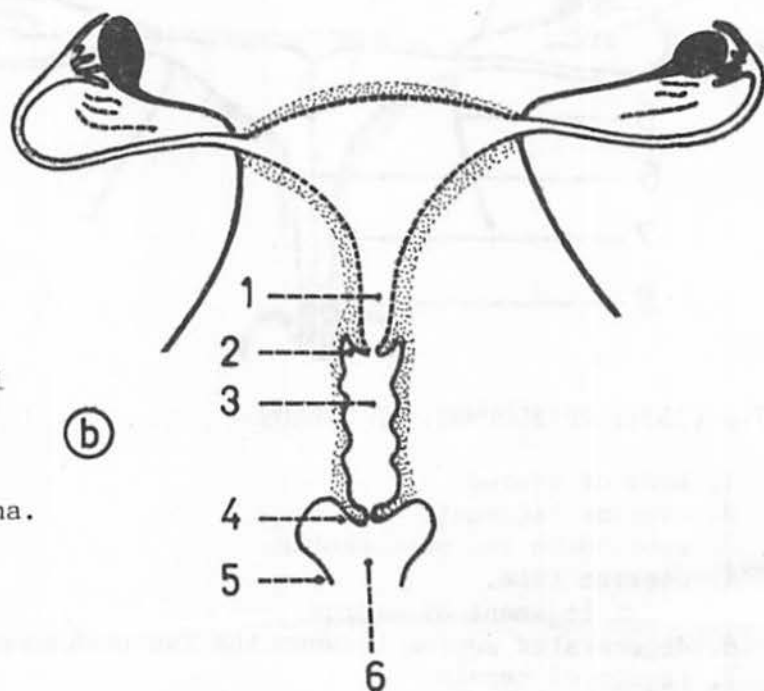
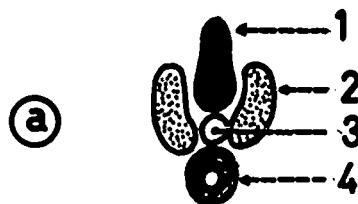


Fig.(235): VULVA
(female external genital organs)

(a) Indifferent stage

1. phallus.
2. labio-scrotal swelling.
3. urogenital membrane.
4. anal orifice.



(b) Advanced stage

1. clitoris.
2. labium majus (from labio-scrotal swelling).
3. labium minor (from genital folds of ruptured urogenital membrane).
4. vestibule of vagina.
5. anal orifice.

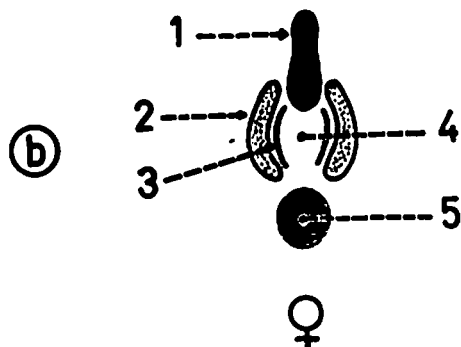
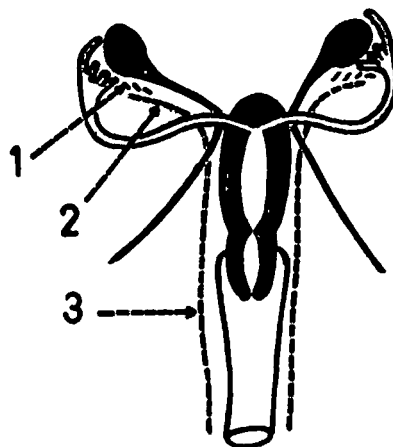


Fig.(236): ABNORMAL PERSISTENCE OF MESONEPHRIC DUCT IN THE FEMALE

1. epoophoron (close to the ovary).
2. paroophoron (close to the uterine tube).
3. Gartner's duct (along the side of the uterus or vagina).



ANOMALIES OF FEMALE GENITAL ORGANS

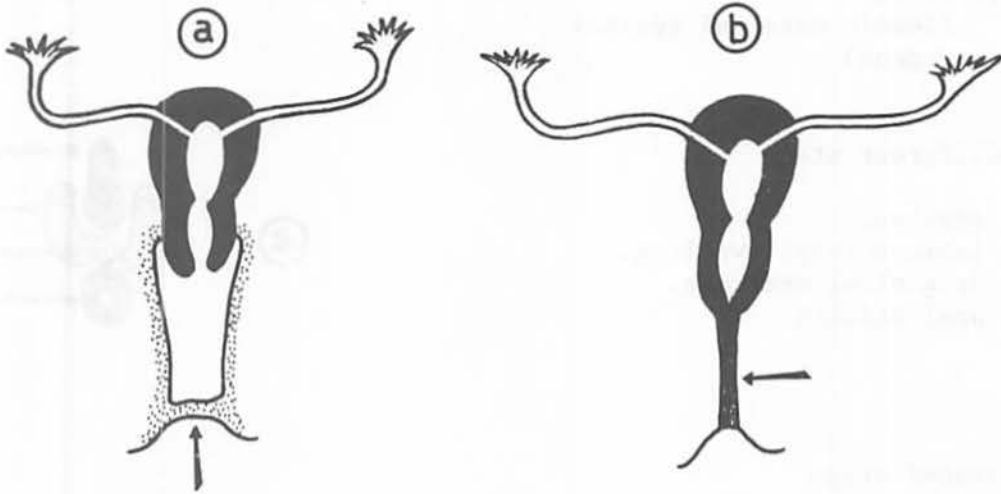


Fig.(237): ANOMALIES OF VAGINA

(a) Imperforate hymen

(b) Atresia of vagina (failure of formation)

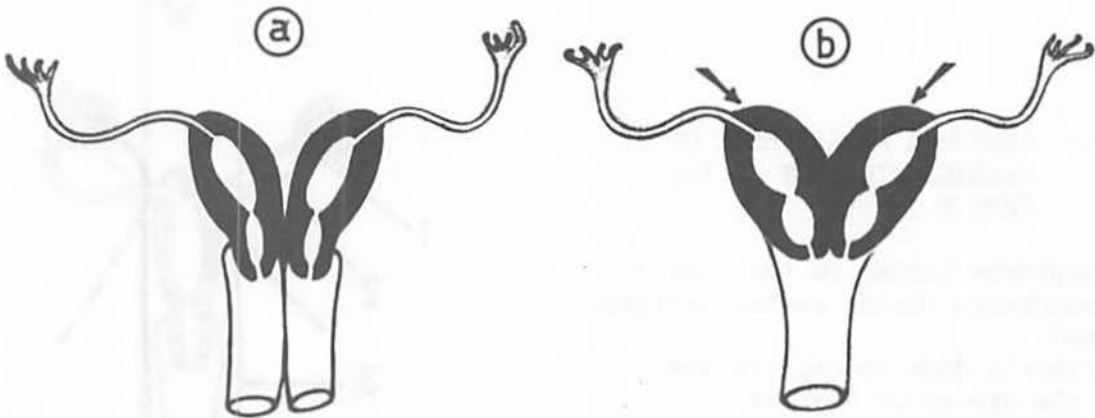


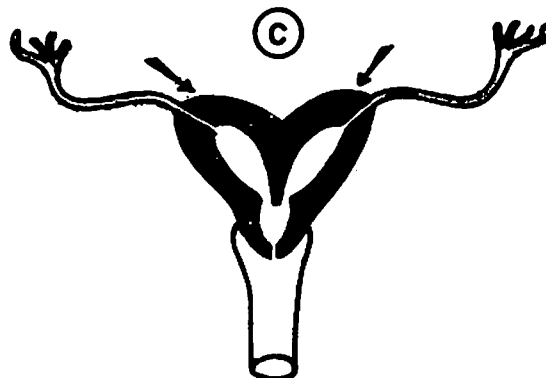
Fig.(238): ANOMALIES OF UTERUS

(a) Uterus didelphys:
Double uterus with double vagina, each uterus has one uterine tube only.(b) Uterus bicornis bicollis:
Single uterus with two horns (arrows) and two cervices with one vagina.

ANOMALIES OF UTERUS (continued)

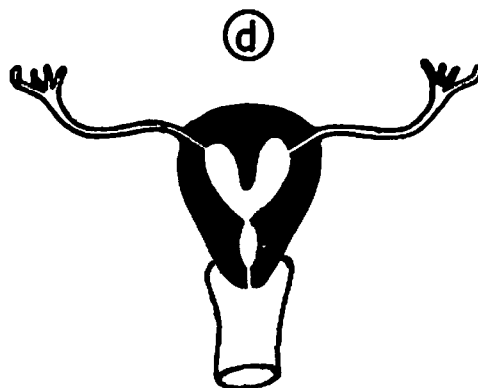
(c) Uterus bicornis unicollis:

Single uterus with two horns (arrows) and one cervix.



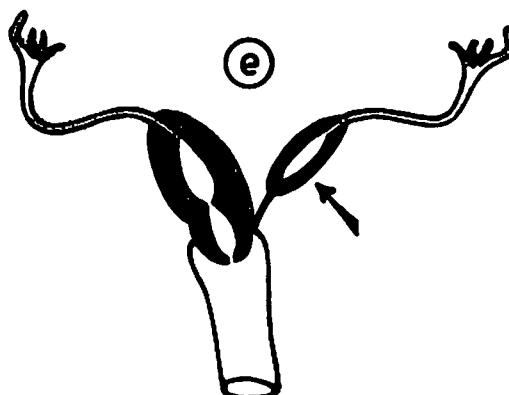
(d) Septate uterus (uterus bipartite):

Single uterus with its body partially divided by a septum (note the normal fundus and the absence of horns).



(e) Uterus unicornis:

Uterus with one normal horn while the other horn is rudimentary (arrow).



ENDOCRINE GLANDS

THYROID GLAND

Fig.(239): FORAMEN CAECUM
(in the floor of pharynx)

1. lingual swelling.
2. tuberculum impar.
3. foramen caecum (site of origin of thyroglossal duct).
4. hypobranchial eminence.

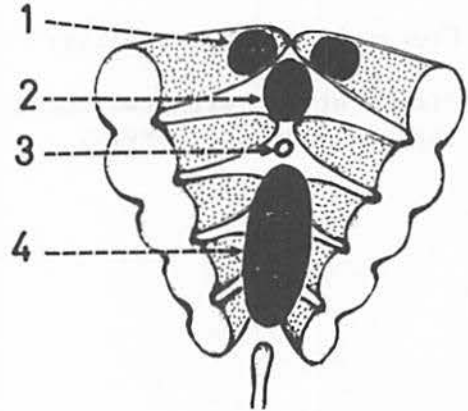
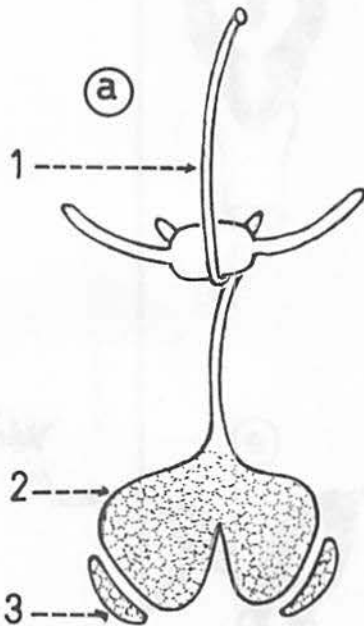
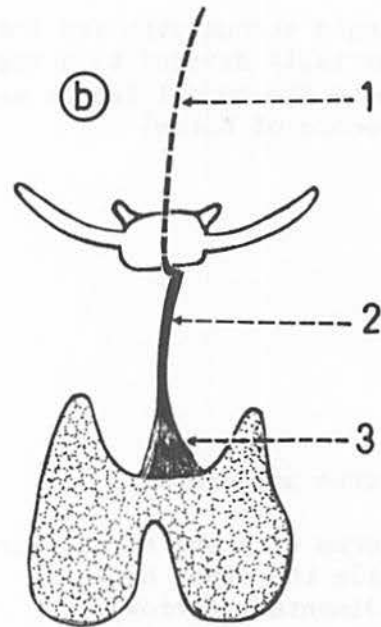


Fig.(240): DEVELOPMENT OF THYROID GLAND



(a) Early stage (thyroglossal duct)

1. thyroglossal duct.
2. lobes of early thyroid.
3. contribution from 4th pharyngeal pouch.



(b) Advanced stage

1. degenerated thyroglossal duct.
2. levator glandulae thyroideae.
3. pyramidal lobe.

Fig.(241): COURSE OF THYROGLOSSAL DUCT

1. foramen caecum.
2. course inside the tongue.
3. course in front, below and behind the body of hyoid bone.
4. course in front of thyroid cartilage.
5. final position of thyroid gland.

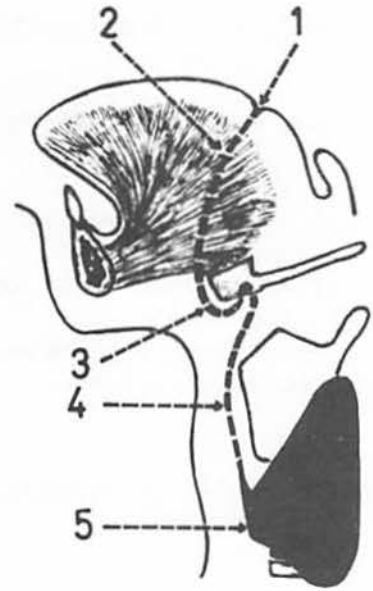


Fig.(242): SITES OF THYROGLOSSAL CYSTS (remnants of thyroglossal duct)

1. in the tongue.
2. in front of hyoid bone.
3. behind hyoid bone.
4. in front of thyroid cartilage.

N.B.: Thyroglossal cysts lie in the midline of the neck, and 50% of them lie around the hyoid bone.

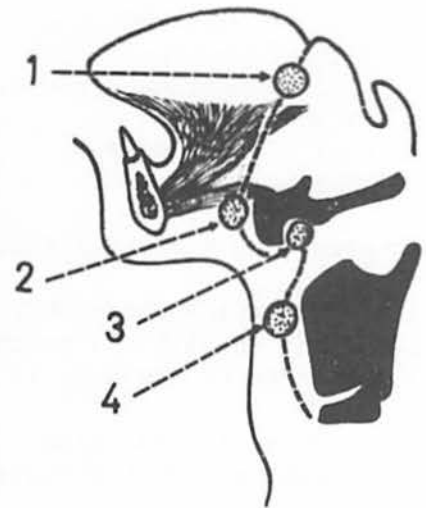


Fig.(243): LINGUAL THYROID

1. foramen caecum.
2. lingual thyroid.



HYPOPHYSIS CEREBRI (PITUITARY GLAND)

Fig.(244): ORIGIN OF HYPOPHYSIS CEREBRI

1. infundibulum (from floor of diencephalon).
2. Rathke's pouch (from roof of stomodeum).
3. buccopharyngeal membrane.
4. pericardial bulge.

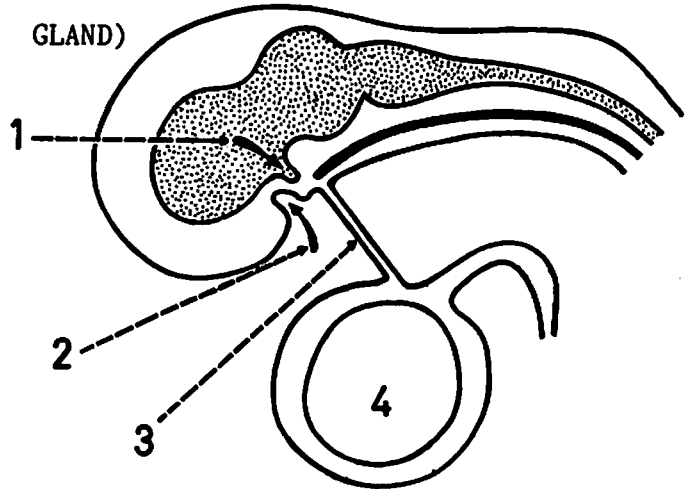
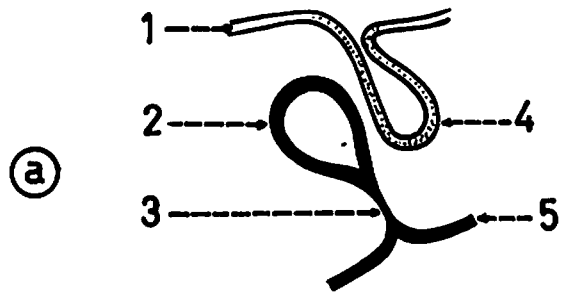


Fig.(245): LOBES OF HYPOPHYSIS CEREBRI

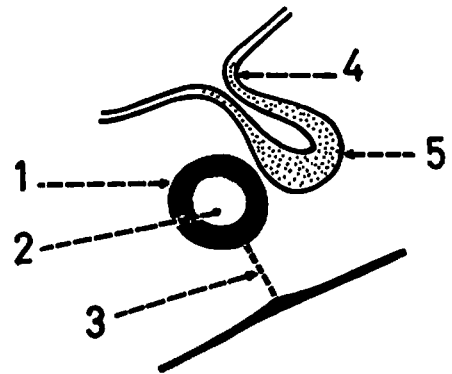
(a) Early stage

1. floor of diencephalon.
2. Rathke's pouch.
3. stalk of Rathke's pouch.
4. infundibulum.
5. roof of stomodeum.



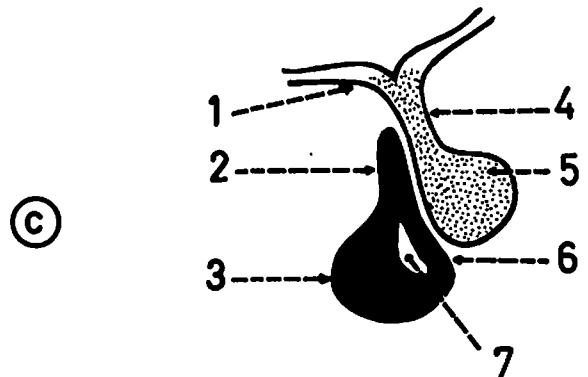
(b) Anterior and posterior lobes

1. anterior lobe (adenohypophysis).
2. cavity of Rathke's pouch.
3. degenerated stalk of Rathke's pouch.
4. stalk of infundibulum.
5. posterior lobe (neurohypophysis).



(c) Final stage

1. tuber cinerium.
2. pars tuberalis.
3. pars anterior.
4. stalk of infundibulum.
5. posterior lobe.
6. pars intermedia.
7. remnant of cavity of Rathke's pouch.



SUPRARENAL GLAND

Fig.(246): ORIGIN OF SUPRARENAL GLAND

1. neural crest.
2. medulla of suprarenal (ectodermal from neural crest).
3. cortex of suprarenal (mesodermal).
4. coelomic cavity.
5. gut.

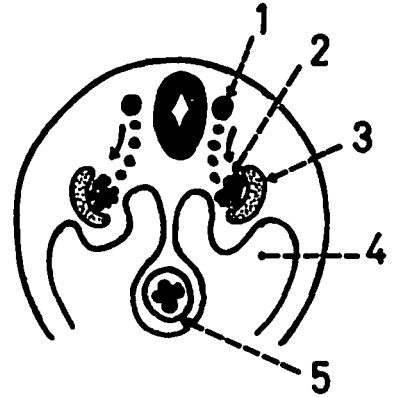
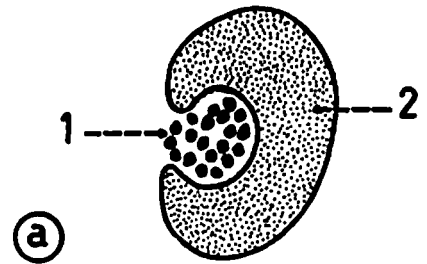


Fig.(247): STAGES OF SUPRARENAL GLAND

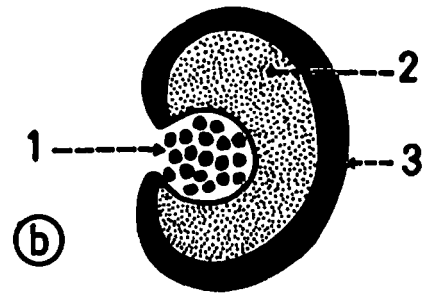
(a) Early stage

1. suprarenal medulla.
2. foetal cortex.



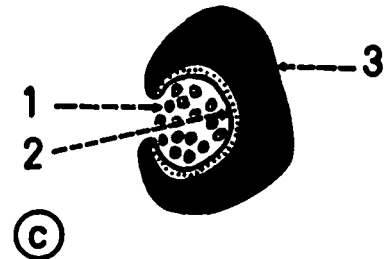
(b) Appearance of definitive cortex

1. suprarenal medulla.
2. foetal cortex.
3. thin definitive cortex.



(c) After birth

1. suprarenal medulla.
2. thin foetal cortex.
3. thick definitive cortex.



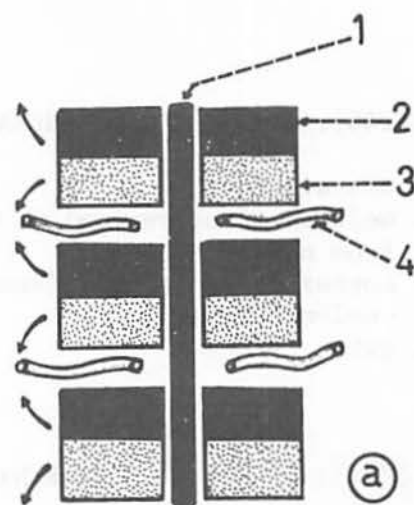
BONES AND INTEGUMENTARY SYSTEM

BONES

Fig.(248): DEVELOPMENT OF VERTEBRAL COLUMN

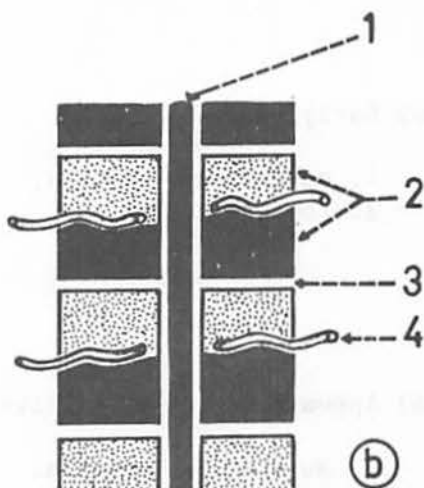
(a) Early stage (sclerotomes)

1. notochord.
2. cranial part of sclerotome.
3. caudal part of sclerotome.
4. intersegmental artery (between two sclerotomes).



(b) Formation of vertebral bodies and intervertebral discs

1. notochord.
2. body of vertebra (from two sclerotomes).
3. intervertebral disc (from the middle of sclerotome).
4. intersegmental artery (crosses the middle of the vertebra).



(c) Advanced stage

1. vertebral body (showing degeneration of notochord).
2. intervertebral disc (showing nucleus pulposus from persistent notochord).
3. intersegmental artery.
4. degenerated notochord.

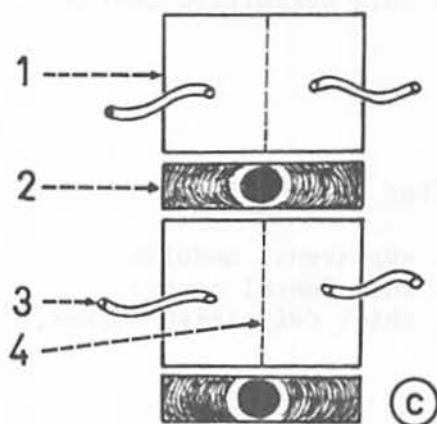
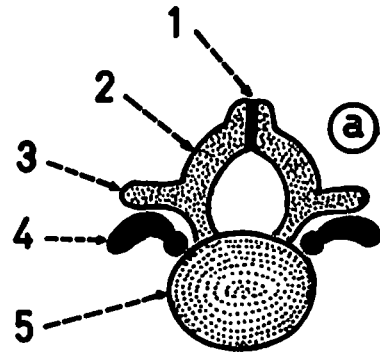


Fig.(249): DEVELOPMENT OF VERTEBRA

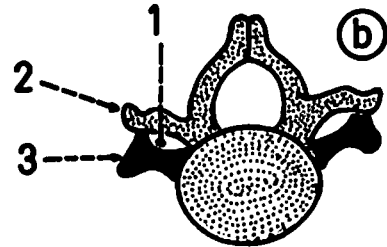
(a) Thoracic vertebra

1. spine.
2. lamina.
3. transverse process.
4. costal process (for rib).
5. vertebral body.



(b) Cervical vertebra

1. foramen transversarium.
2. transverse process proper.
3. costal process.



(c) Spina bifida

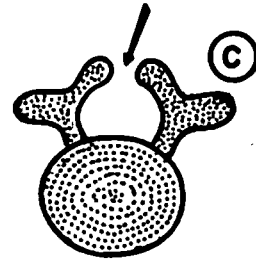
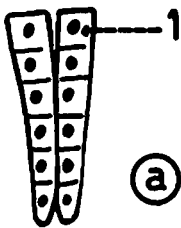
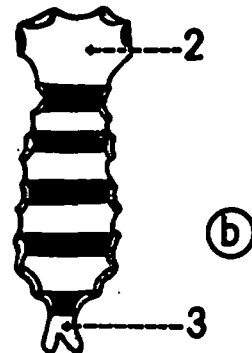


Fig.(250): DEVELOPMENT OF STERNUM

(a) Two sternal bars
(each is divided into six segments)

1. ossification centre.



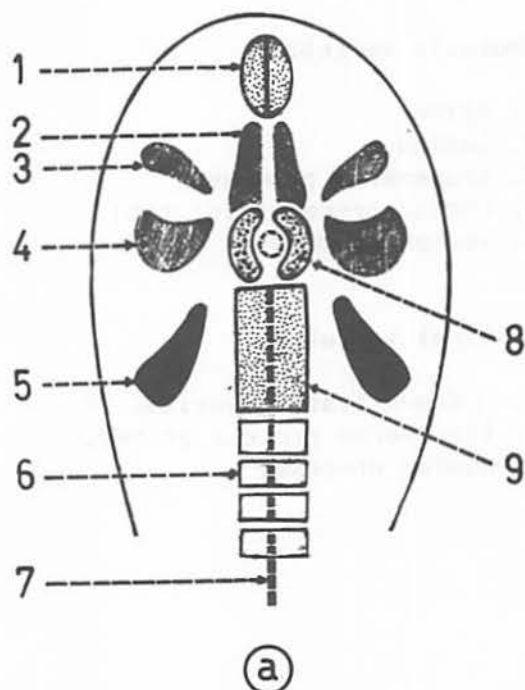
(b) Sternum with six sternbrae

2. 1st sternebra (manubrium).
3. 6th sternebra (xiphoid process).

Fig.(251): DEVELOPMENT OF SKULL

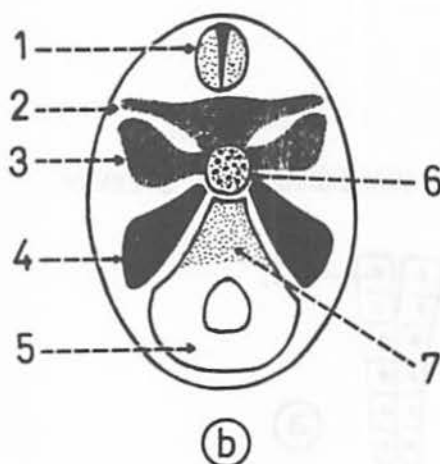
(a) Early stage

1. nasal capsule.
2. trabecular cartilage.
3. ala orbitalis.
4. ala temporalis.
5. otic capsule.
6. occipital somites.
7. notochord.
8. hypophyseal cartilage.
9. parachordal plate.



(b) Advanced stage

1. ethmoid bone (from nasal capsule).
2. lesser wing of sphenoid (from ala orbitalis).
3. greater wing of sphenoid (from ala temporalis).
4. petrous part of temporal bone (from otic capsule).
5. occipital bone (from occipital sclerotomes).
6. body of sphenoid (from fused hypophyseal and trabecular cartilages).
7. clivus (from parachordal plate).



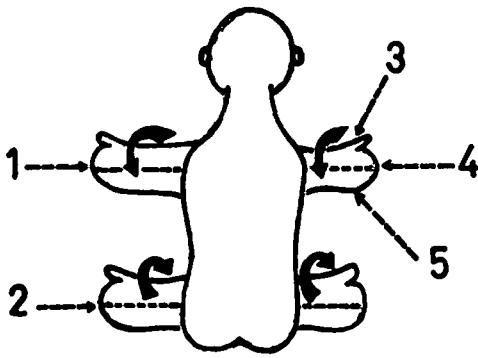


Fig.(252): ROTATION OF LIMB BUDS

1. upper limb bud (rotated laterally).
2. lower limb bud (rotated medially).
3. preaxial border.
4. axis of limb.
5. postaxial border.

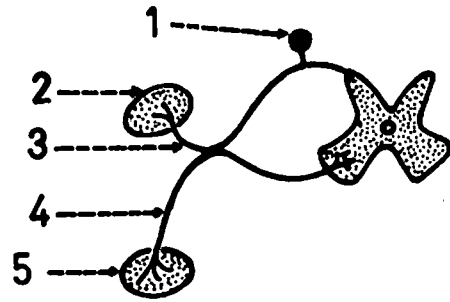
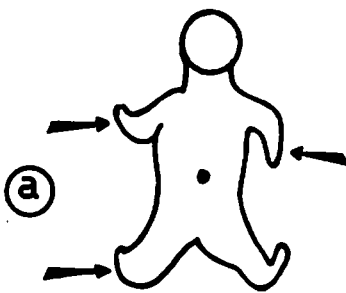


Fig.(253): SUBDIVISION OF MYOTOMES

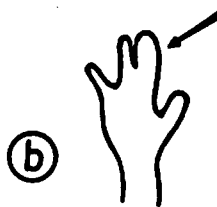
1. dorsal root ganglion.
2. dorsal part of myotome.
3. dorsal primary ramus.
4. ventral primary ramus.
5. ventral part of myotome.

Fig.(254): ANOMALIES OF THE LIMBS



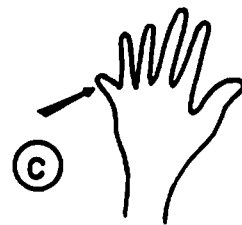
(a) Amelia

(failure of complete formation of limb buds)



(b) Syndactyly

(fusion of fingers)

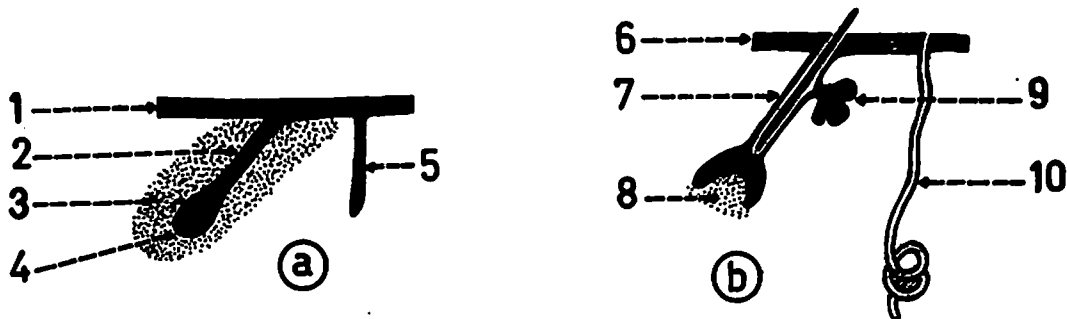


(c) Polydactyly

(presence of extra digits)

INTEGUMENTARY SYSTEM

Fig.(255): DEVELOPMENT OF SKIN



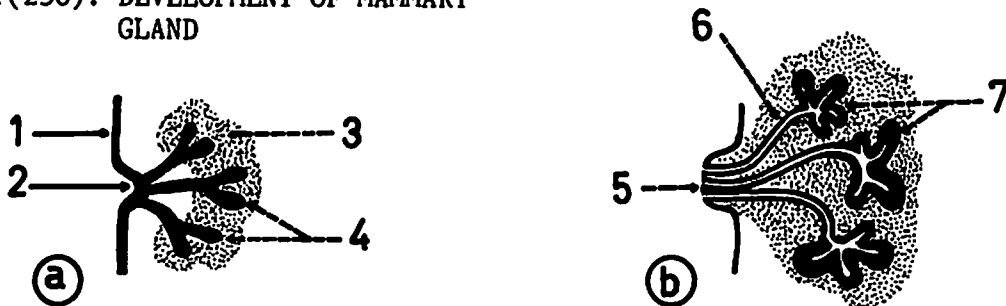
(a) Early stage

1. surface ectoderm.
2. solid ectodermal cord (for hair).
3. underlying mesoderm.
4. hair bulb.
5. solid ectodermal cord (for sweat gland).

(b) Advanced stage

6. epidermis.
7. shaft of hair.
8. hair papilla.
9. sebaceous gland.
10. sweat gland.

Fig.(256): DEVELOPMENT OF MAMMARY GLAND



(a) Early stage

1. thick ectoderm of milk (mammary) line.
2. pit for nipple.
3. underlying mesoderm.
4. ectodermal cords for lactiferous tubules.

(b) Advanced stage

5. everted nipple.
6. lactiferous duct.
7. lobule of mammary gland.

Fig.(257): MILK (MAMMARY) LINE

(extends from the axilla
to the inguinal region)

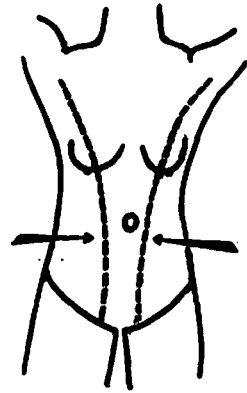
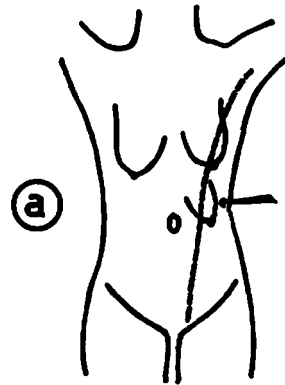


Fig.(258): ANOMALIES OF MAMMARY GLAND

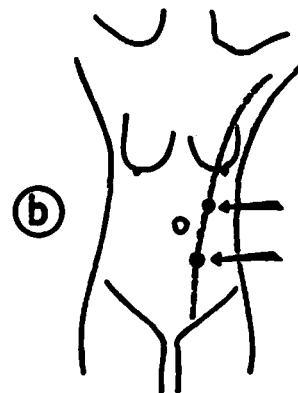
(a) Polymastia

(presence of more than one
complete mammary gland along
the milk line)



(b) Polythelia

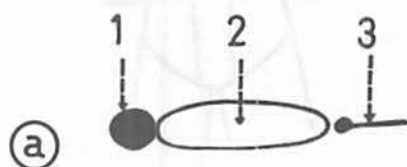
(presence of more than one
nipple along the milk line)



CENTRAL NERVOUS SYSTEM

SPINAL CORD

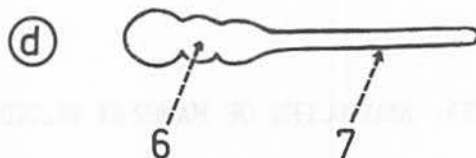
Fig.(259): FORMATION OF NEURAL TUBE



(a) Neural plate

(b) Neural groove

1. buccopharyngeal membrane.
2. neural plate.
3. primitive streak.

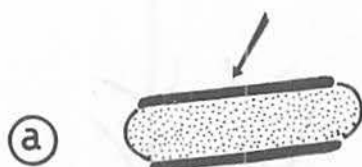


(c) neural tube with 2 neuropores

(d) complete neural tube

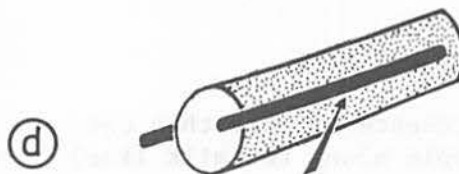
4. anterior neuropore.
5. posterior neuropore.
6. brain vesicle.
7. spinal cord.

Fig.(260): FORMATION OF NEURAL CREST



(a) At the edge of neural plate

(b) At the edge of neural fold



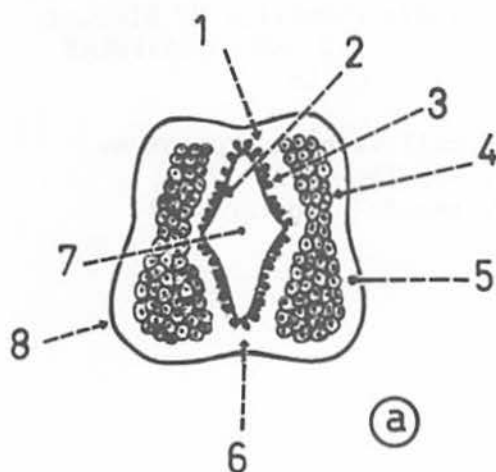
(c) Close to the midline of neural tube

(d) Migrated ventrally to lie on the side of neural tube

Fig.(261): DEVELOPMENT OF SPINAL CORD

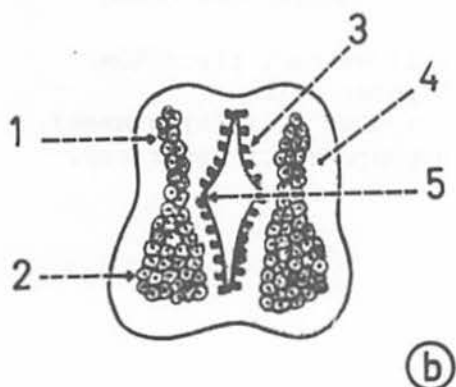
(a) Early stage

1. roof plate.
2. internal limiting membrane.
3. ependymal layer.
4. mantle layer.
5. marginal layer.
6. floor plate.
7. lumen of neural tube (future central canal).
8. external limiting membrane.



(b) Formation of alar and basal laminae

1. alar lamina (sensory).
2. basal lamina (motor).
3. ependymal layer.
4. marginal layer.
5. sulcus limitans.



(c) Formation of grey horns

1. dorsal root ganglion.
2. dorsal horn (sensory).
3. lateral horn (autonomic).
4. ventral horn (motor).
5. ventral root of spinal nerve.

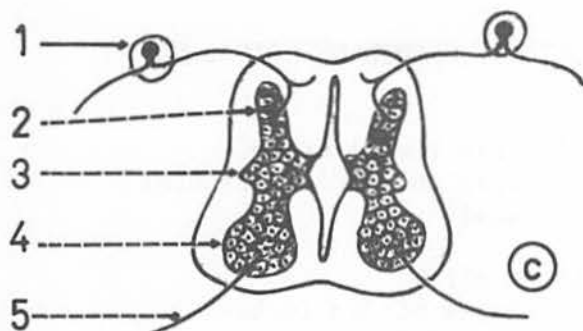


Fig.(262): FORMATION OF BIPOLAR AND PSEUDO-UNIPOLAR CELLS

1. cell without processes.
2. bipolar cell.
3. pseudo-unipolar cell.

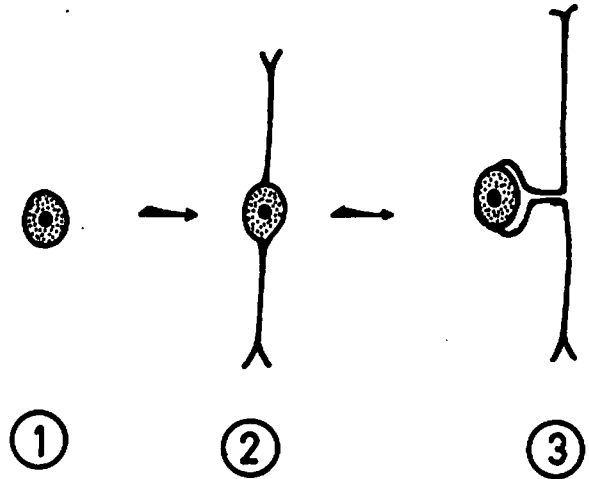


Fig.(263): FORMATION OF MULTIPOLAR CELLS

1. cell without processes.
2. bipolar cell.
3. unipolar cell (with axon).
4. appearance of dendrites.

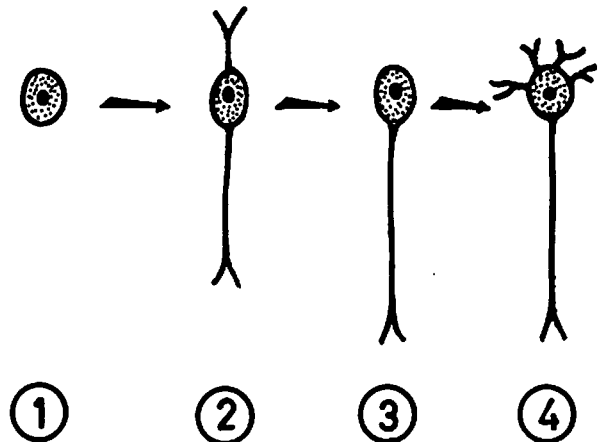


Fig.(264): GROWTH OF SPINAL CORD

- (a) Early foetal stage
(fills the whole vertebral canal)
- (b) At birth
(level of 3rd lumbar vertebra)
- (c) After 3rd month of birth
(level of disc between 1st and 2nd lumbar vertebrae)

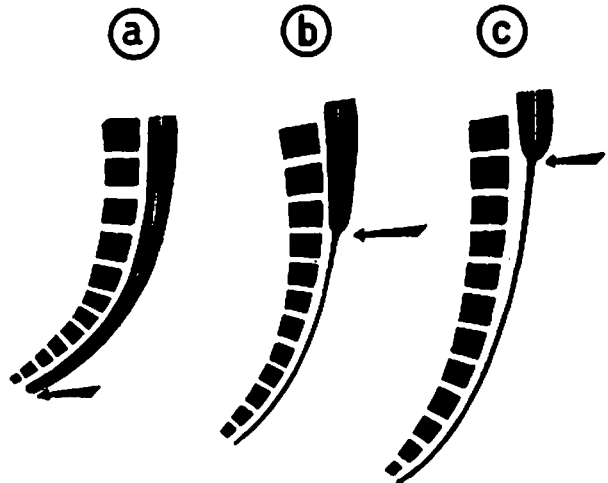
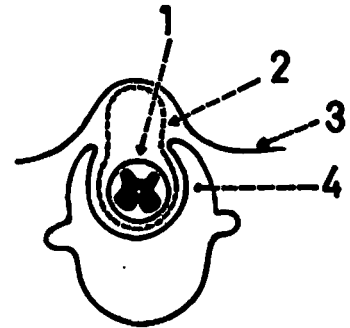


Fig.(265): ANOMALIES OF SPINAL CORD

(a) Meningocele

(protrusion of meninges through a defect of spina bifida)

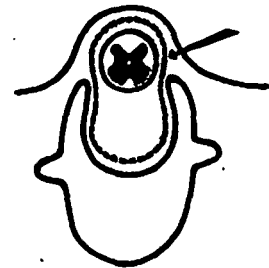
1. spinal cord.
2. meninges.
3. skin.
4. vertebra with spina bifida.



(a)

(b) Meningomyelocele

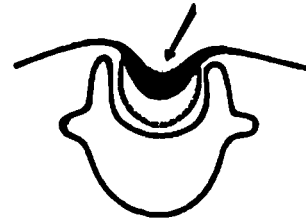
(protrusion of both spinal cord and its meninges through a spina bifida)



(b)

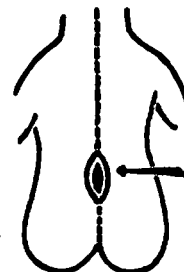
(c) Myelocele

(failure of fusion of the neural tube which is exposed on the surface through a spina bifida)



(c)

(d) Myelocele as seen on the back



(d)

BRAIN STEM

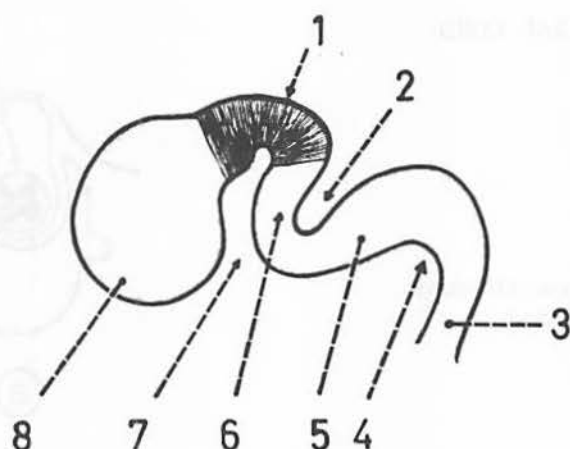


Fig.(266): FORMATION OF BRAIN VESICLES

1. midbrain vesicle (mesencephalon).
2. pontine flexure.
3. spinal cord.
4. cervical flexure.
5. myelencephalon (medulla oblongata).
6. metencephalon (pons).
7. mesencephalic flexure.
8. forebrain vesicle (prosencephalon).

N.B.: The myelencephalon and metencephalon together form the hind brain vesicle (rhombencephalon).

Fig.(267): WALL OF BRAIN STEM

(a) Region of closed medulla

(b) Region of 4th ventricle

1. roof plate.
2. alar lamina.
3. basal lamina.
4. floor plate.
5. central canal.
6. 4th ventricle.

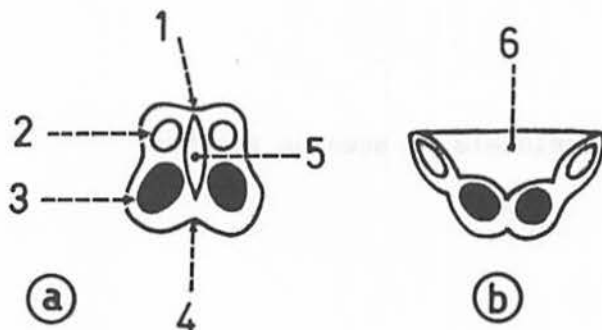


Fig.(268): RHOMBENCEPHALON
(hind brain)

1. alar lamina of metencephalon.
2. rhombic lip.
3. alar lamina of myelencephalon.
4. basal lamina of myelencephalon.
5. basal lamina of metencephalon.

- (a) Plane of T.S. in metencephalon.
(b) Plane of T.S. in myelencephalon.

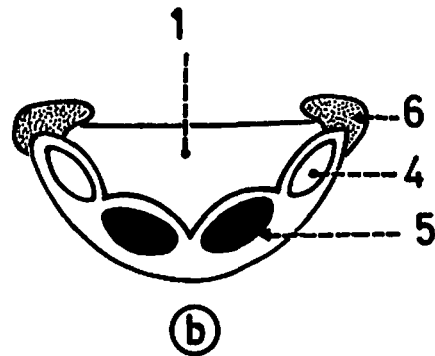
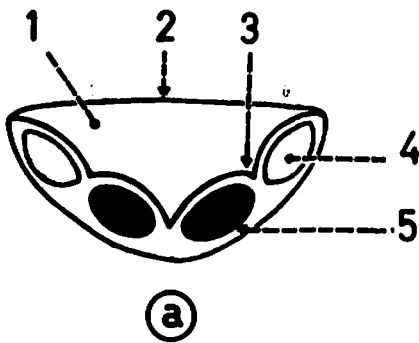
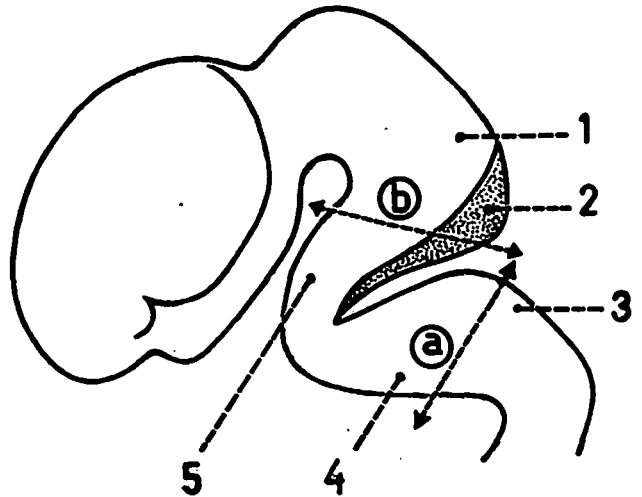


Fig.(269): T.S. IN RHOMBENCEPHALON
(refer to fig.268)

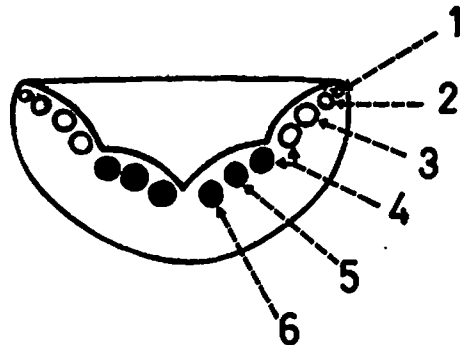
- (a) T.S. in myelencephalon

- (b) T.S. in metencephalon

1. 4th ventricle.
2. roof of 4th ventricle.
3. sulcus limitans.
4. alar lamina.
5. basal lamina.
6. rhombic lip.

Fig.(270): DIFFERENTIATION OF BASAL AND ALAR LAMINAE INTO COLUMNS OF NUCLEI

1. special somatic afferent column.
2. somatic afferent column.
3. special visceral afferent column.
4. general visceral afferent column and general visceral efferent column.
5. special visceral efferent column.
6. somatic efferent column.



N.B.: The efferent columns are motor, while the afferent columns are sensory. The special visceral columns supply structures derived from the branchial arches.

Fig.(271): ARRANGEMENT OF CRANIAL NERVE NUCLEI (T.S. in metencephalon)

1. special somatic afferent (vestibular nuclei).
2. somatic afferent (sensory nuclei of trigeminal).
3. special visceral afferent (nucleus of tractus solitarius, but is not present in the pons).
4. general visceral afferent and efferent (superior salivary nucleus).
5. special visceral efferent (motor nucleus of facial).
6. somatic efferent (abducent nucleus).
7. pontine nuclei (migrated from alar lamina).
8. rhombic lip

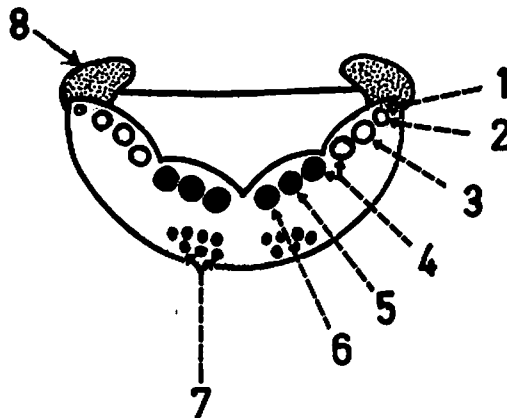
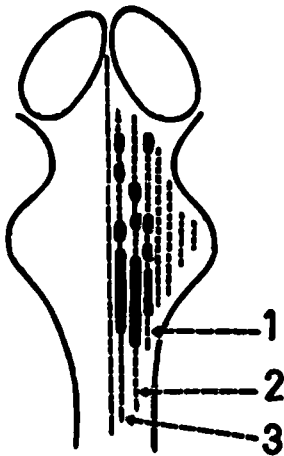
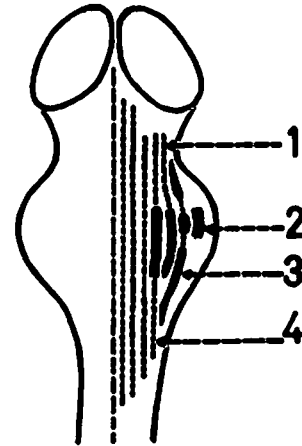


Fig.(272): ARRANGEMENT OF COLUMNS OF NUCLEI
IN THE BRAIN STEM (L.S.)



(a)



(b)

(a) Efferent (motor) nuclei

1. general visceral efferent:
dorsal nucleus of vagus,
inferior salivary nucleus,
superior salivary nucleus
and Edinger-Westphal
nucleus.
2. special visceral efferent:
nucleus ambiguus, motor
nucleus of facial and
motor nucleus of trigeminal.
3. somatic efferent:
nuclei of hypoglossal,
abducent, trochlear and
oculomotor.

(b) Afferent (sensory) nuclei

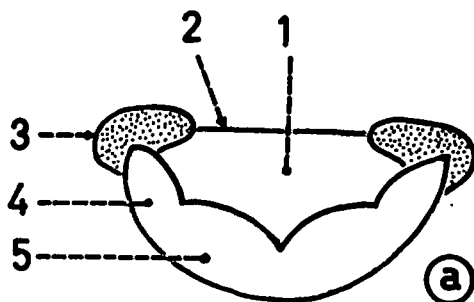
1. special visceral afferent:
nucleus of tractus solitarius
(for taste).
2. special somatic afferent:
auditory nuclei (8th nerve).
3. somatic afferent:
sensory nuclei of trigeminal
(spinal nucleus, main sensory
nucleus and mesencephalic
nucleus).
4. general visceral afferent:
part of the dorsal nucleus of
vagus.

CEREBELLUM

Fig.(273): DEVELOPMENT OF CEREBELLUM

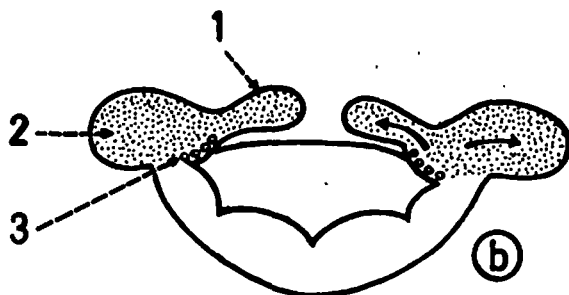
(a) Formation of rhombic lip

1. 4th ventricle.
2. roof of 4th ventricle.
3. rhombic lip.
4. alar lamina.
5. basal lamina.



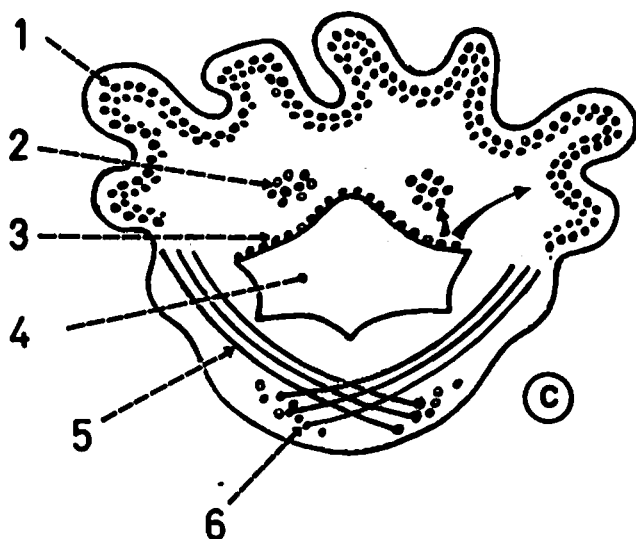
(b) Formation of vermis and lobes

1. vermis.
2. lobe of cerebellum.
3. ependymal cells (migrate to form the cerebellar cortex and cerebellar nuclei).



(c) Formation of cerebellar cortex and nuclei

1. cerebellar cortex.
2. dentate nucleus.
3. cells of ependymal layer.
4. 4th ventricle.
5. ponto-cerebellar fibres.
6. pontine nuclei.



DIENCEPHALON AND TELENCEPHALON

Fig.(274): DIVISIONS OF PROSENCEPHALON
(diencephalon and telencephalon)

1. telencephalon (cranial part of prosencephalon).
2. diencephalon (caudal part of prosencephalon, behind the lateral diverticulum).
3. lamina terminalis.
4. interventricular foramen (of Monro).
5. lateral diverticulum (future cerebral hemisphere).
6. mesencephalon.
7. rhombencephalon.
8. spinal cord.

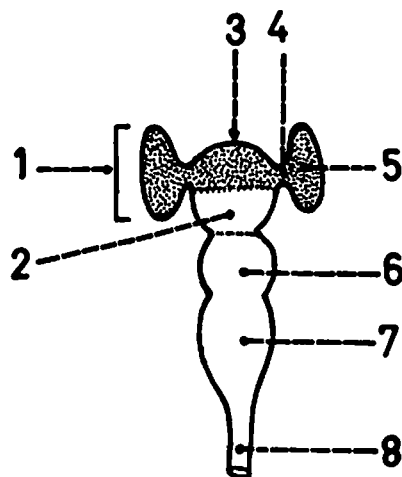
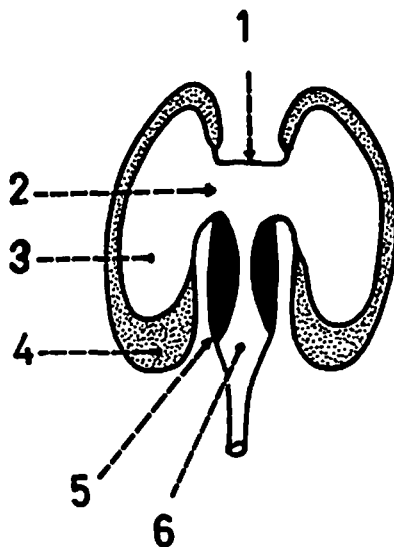


Fig.(275): ADVANCED STAGE OF PROSENCEPHALON
(coronal section)

1. lamina terminalis.
2. interventricular foramen (of Monro).
3. telencephalic vesicle (future cerebral hemisphere).
4. corpus striatum in the floor of telencephalic vesicle.
5. lateral wall of diencephalon (showing the thalamus).
6. cavity of diencephalon (future 3rd ventricle).



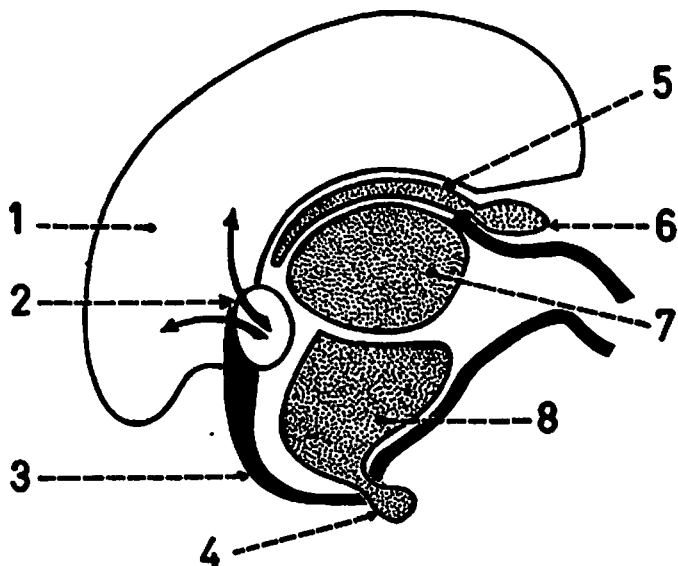


Fig.(276): PARTS OF DIENCEPHALON

1. telencephalic vesicle.
2. interventricular foramen (with arrows entering the telencephalic vesicle).
3. lamina terminalis.
4. infundibulum.
5. epithalamus.
6. pineal body.
7. thalamus.
8. hypothalamus.

Fig.(277): EXPANSION OF TELENCEPHALIC VESICLE

1. telencephalic vesicle expanding.
2. mesencephalon.
3. diencephalon.
4. interventricular foramen (of Monroe).

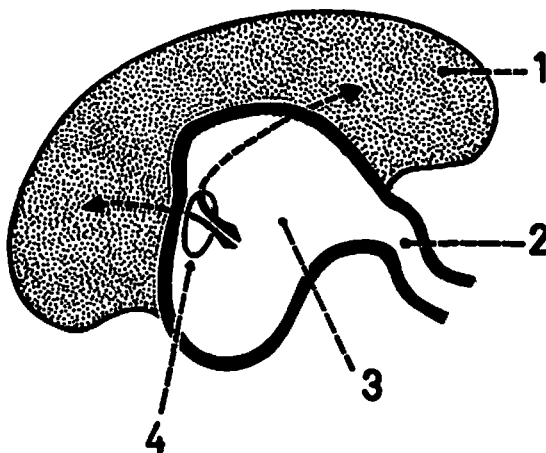
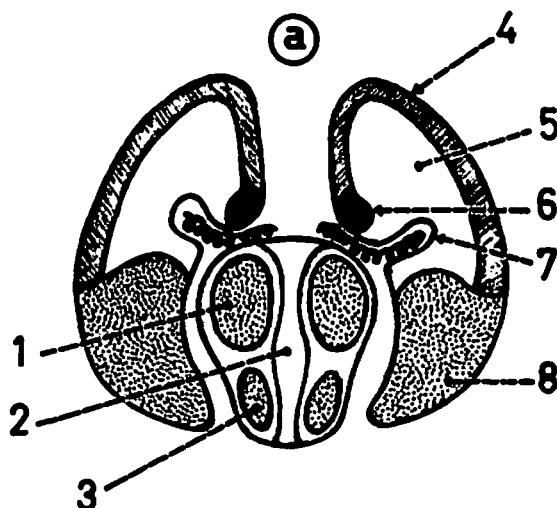


Fig.(278): DEVELOPMENT OF CEREBRAL HEMISPHERE

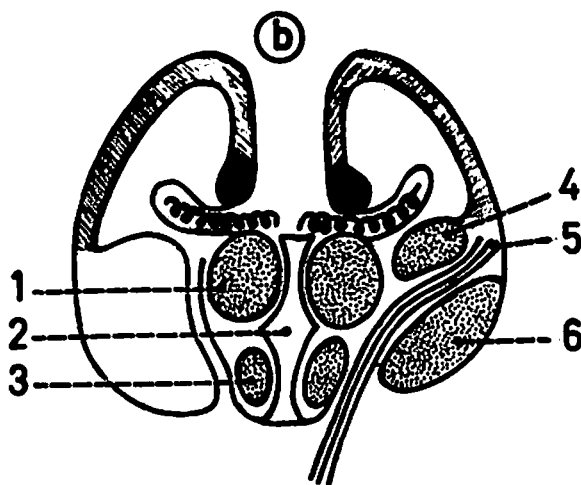
(a) Early stage

1. thalamus.
2. cavity of diencephalon.
3. hypothalamus.
4. pallium.
5. lateral ventricle.
6. hippocampus.
7. choroid plexus passing through the choroidal fissure.
8. corpus striatum.



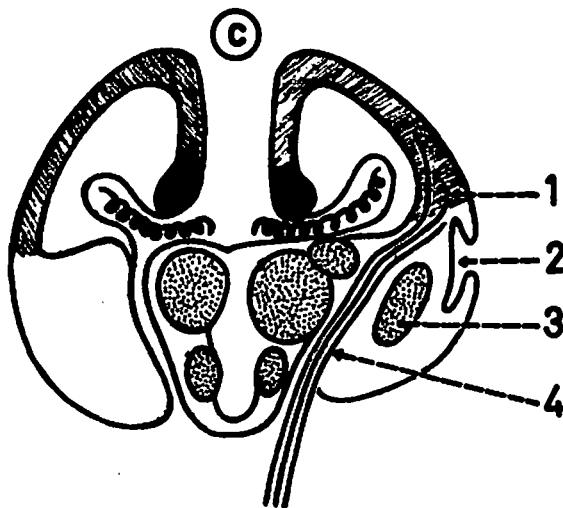
(b) Formation of internal capsule

1. thalamus.
2. 3rd ventricle.
3. hypothalamus.
4. caudate nucleus.
5. internal capsule.
6. lentiform nucleus.



(c) Advanced stage

1. fibres of corona radiata.
2. insula.
3. lentiform nucleus.
4. internal capsule.



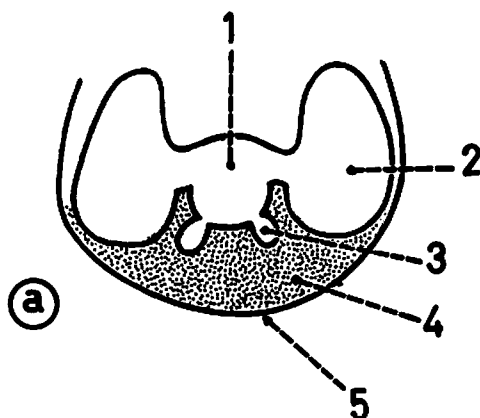
ORGANS OF SPECIAL SENSES

E Y E

Fig.(279): DEVELOPMENT OF OPTIC VESICLE AND OPTIC CUP

(a) Stage of optic vesicle

1. cranial end of prosencephalon.
2. telencephalic vesicle.
3. optic vesicle.
4. mesoderm under the surface ectoderm.
5. surface ectoderm.



(b) Stage of optic cup

1. optic stalk.
2. optic cup.
3. lens placode (ectodermal).
4. surface ectoderm.
5. underlying mesoderm.

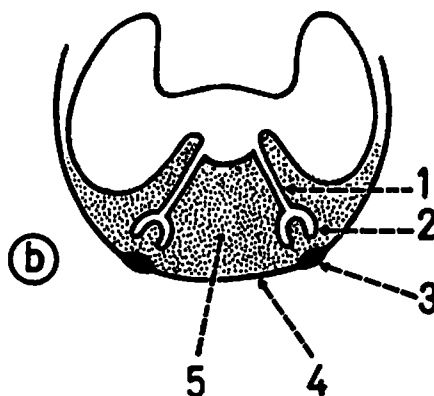


Fig.(280): FORMATION OF LENS AND CHOROIDAL FISSURE

(a) Lens placode

(b) Lens vesicle

1. lens placode (thickening on the surface).
2. underlying mesoderm.
3. optic cup.
4. choroidal fissure (on the under surface of the cup and its stalk).
5. optic stalk.
6. hyaloid artery (in the fissure).
7. lens vesicle.

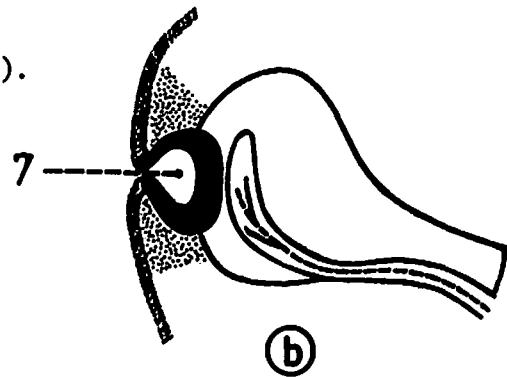
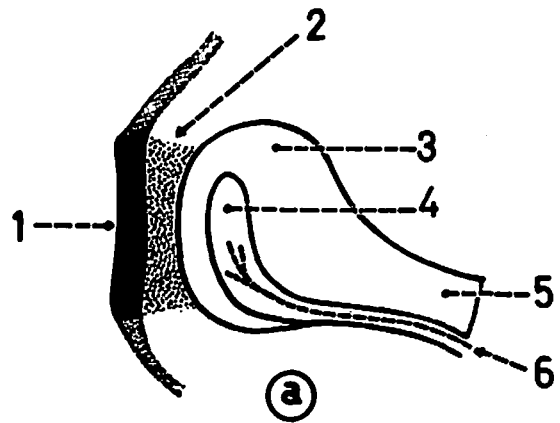
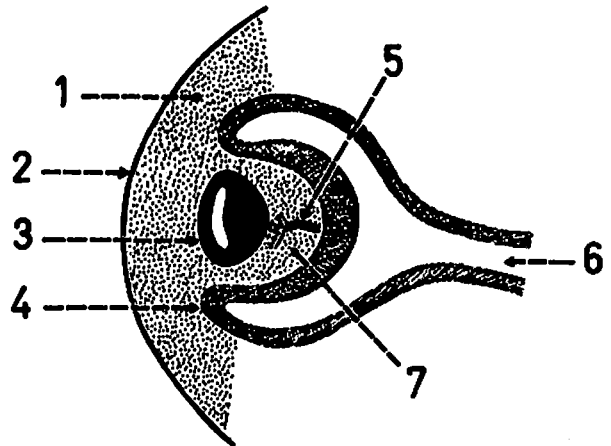


Fig.(281): SINKING OF THE LENS VESICLE INTO UNDERLYING MESODERM

1. underlying mesoderm.
2. surface ectoderm.
3. lens vesicle (with cavity).
4. edge of optic cup.
5. hyaloid artery going to the lens vesicle.
6. optic stalk.
7. future vitreous body.



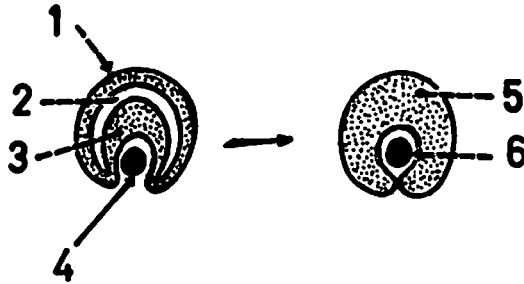


Fig.(282): CLOSURE OF CHOROIDAL FISSURE

1. outer layer of optic stalk.
2. cavity of optic stalk.
3. inner layer of optic stalk.
4. hyaloid artery in the choroid fissure.
5. optic nerve (advanced stage).
6. central artery of retina in the optic nerve.

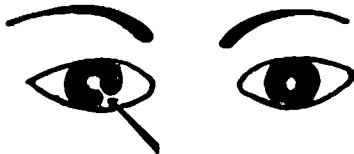


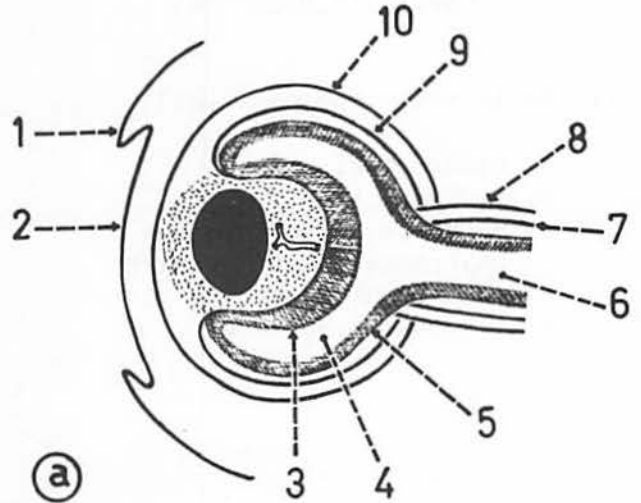
Fig.(283): CONGENITAL COLOBOMA OF THE IRIS

(it is a defect in the iris due to failure of closure of the choroid fissure at the edge of the optic cup)

Fig.(284): COATS OF EYEBALL

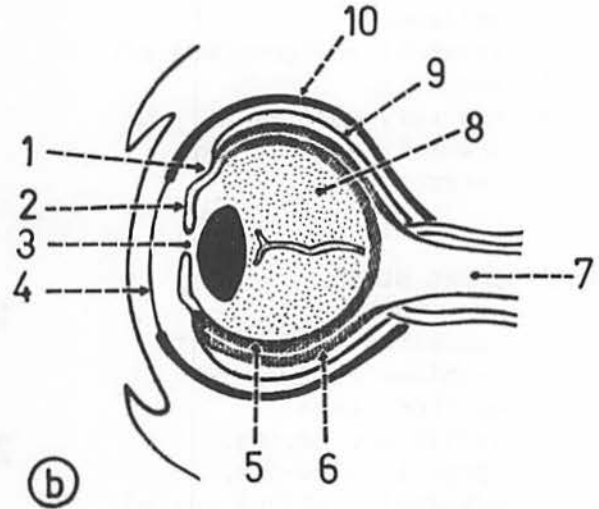
(a) Early stage

1. eye lid.
2. conjunctiva.
3. inner layer of optic cup (pars optica).
4. cavity of optic cup (intra-retinal space).
5. outer layer of optic cup (pigmented part).
6. optic stalk.
7. pia-arachnoid mater.
8. dura mater.
9. vascular coat of eyeball.
10. fibrous coat of eyeball.



(b) Advanced stage

1. ciliary body.
2. iris.
3. pupil.
4. cornea.
5. inner layer of retina.
6. outer layer of retina.
7. optic nerve.
8. vitreous body with hyaloid artery going to the lens.
9. choroid (vascular pigmented coat).
10. sclera (fibrous coat).

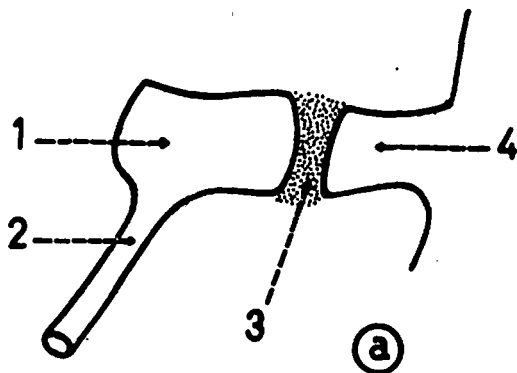


E A R

Fig.(285): DEVELOPMENT OF TYMPANIC CAVITY (MIDDLE EAR)

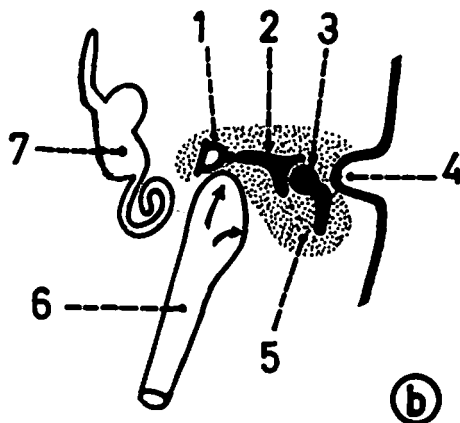
(a) Early stage (no ossicles)

1. middle ear.
2. auditory tube.
3. mesoderm between 1st pharyngeal cleft and 1st pharyngeal pouch.
4. 1st pharyngeal cleft.



(b) Formation of middle ear ossicles

1. stapes.
2. incus.
3. malleus.
4. external auditory meatus.
5. mesoderm.
6. auditory tube with primitive middle ear.
7. internal ear.



(c) Advanced stage

1. semicircular ducts.
2. cochlear duct.
3. auditory tube.
4. middle ear cavity.
5. tympanic membrane.
6. external auditory meatus.

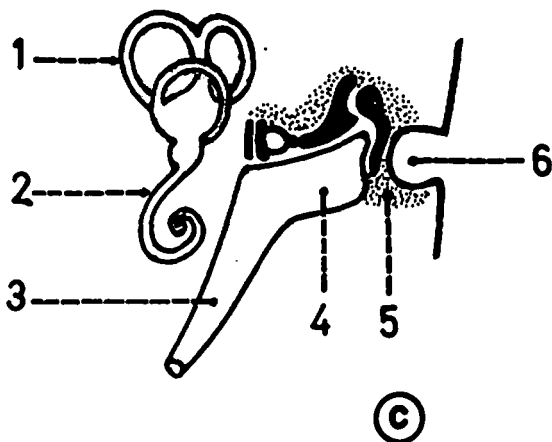
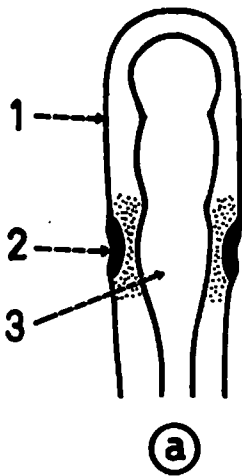
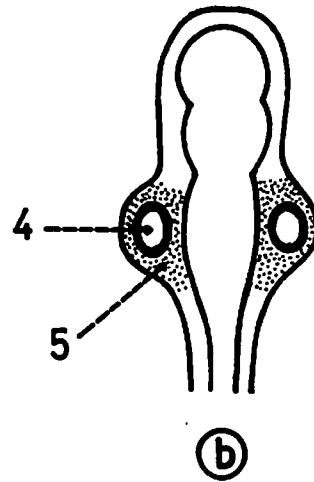


Fig.(286): DEVELOPMENT OF INTERNAL EAR



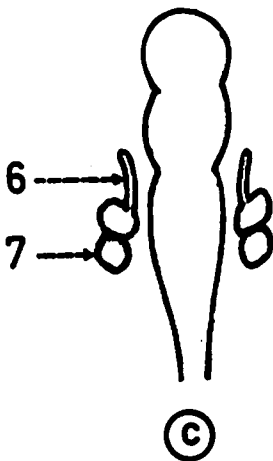
(a) Otic placode

1. surface ectoderm.
2. otic placode (ectodermal thickening).
3. cavity of hind brain.



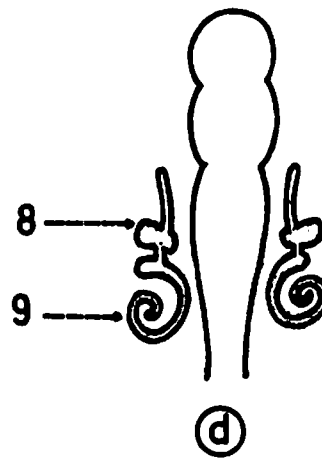
(b) Otic vesicle (otocyst)

4. otocyst.
5. underlying mesoderm.



(c) Early otocyst

6. vestibular part.
7. cochlear part.



(d) Late otocyst

8. early semicircular ducts.
9. early cochlear duct.



